

Comparative Biochemistry - Outline

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Schwartz
Chemistry 245
E.L.T.A.T.W.Y.
Jan-Mar 1941

I - Methods of obtaining energy

- evolutionary development
- mechanisms & reactions involved
 - respiratory mediators
 - similarity of mechanisms in various scales of life
 - nucleotides, coenzymes, enzymes, C₄ dicarboxylic acids etc.
 - analogies of amino acid & carbohydrate catabolism.

II Utilization of energy for life.

- growth
- restoration of cell material, hence syntheses.

III Syntheses by cell

- carbohydrates, amino acids, proteins etc.
- inability to synthesize certain things (vitamins etc.) This represents a progressive (evolutionary) loss of power to synthesize by the organism.
- Vitamins probably function as catalysts

- ability to synthesize amino acids.
 - nature of essential & non-essential amino acids (that is, structural)

IV Enzymes

- enzymes control:-
 - structural characteristics of organisms reaction
- enzymes may be classified as:-
 - adaptive
 - constitutive
- production of enzymes is controlled genetically

V Some aspects of gene action

- similarity to viruses & phage
 - size, composition, physical properties, etc.
- cause of mutations
- types of reactions which can be modified or controlled genetically
 - vital modifications of metabolism alkaptonuria etc
 - non-vital modifications such as skin pigments of rabbits

- genes have a positive effect
 - dominant gene - results in production of enzymes etc.
 - mutation of genes involves loss of a function - recessive genes
- general nature of action of genes
 - blocking of metabolic reactions
 - a way of arriving at actual number of chemical steps in a synthesis process.
- assume that all processes in cells are genetically controlled

- 1- Give titles and authors of 5 reference books you have found useful in this course.
- 2- What are the distinguishing differences between fermentation and respiration?
- 3- Give a scheme for the oxidation and resynthesis of glycogen, in animal tissues, giving names or formulae of intermediate products.
- 4- What do the following have in common in structure and function?

B ₁	B ₂	nicotinic amide	pyocyanine
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- 5- Discuss very briefly the significance of nucleotides in biological processes.
- 6- State very briefly the main scientific contributions of:

a. Harden	g. Parnas
b. Neuberg	h. Krebs
c. Warburg	i. Kluyver
d. Wieland	j. Scott-Moncrieff
e. Szent Gyorgyi	k. Lwoff
f. Meyerhof	l. Beadle

(as considered in this course)
- 7- Is there any relationship between the following, if so, what?
 - a. Phosphorylase and cytochrome
 - b. Alkaptonuria and alkalosis
 - c. B₁ and acetic acid
 - d. Succinic and keto-glutaric acids
 - e. Symbiotic bacteria and carnivorous animals
 - f. Cytochrome and alcoholic fermentation
- 8- Is an understanding of the principles of heredity of any value to a biochemist? If so, what or why?
- 9- List 5 points of similarity between viruses, phages, and genes.
- 10- In the final analysis what determines the characteristics of a given species of plant or animal?
- 11- What is your frank opinion of this course?
Any suggestions? (Answer not to be counted in grade unless too obviously laudatory, and then only negatively)

Comparative Biochemistry

Chem 205-

1/7/80)

Baldwin - Comparative Biochem

General: . Perspectives on Biochem - Cambridge

- Stephenson
- Pirie
- Baldwin

Comparative Biochem is concerned with the similarities of the underlying principles of biochem.

Defn. or properties of the living: -

- cell structure (most quest. as to whether cell structure is necessary - virus?)
- metabolism (again possible exception is virus).
- growth + reproduction
- motion
- adaption to environment

These are some of the criteria of life - but all are not necessary or fundamental.

Production of energy
 Utilization of energy
 Regulation of processes of a living organism.

Biochemical systems at various evolutionary levels.

1. Inorganic chemicals

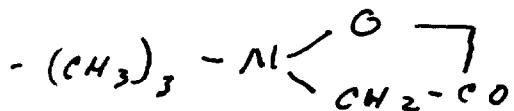
* Blood system :- supposedly similar to sea water. Thought perhaps living organisms can find from sea.

2. Higher organic chemicals - wide spread throughout various living organisms.

- NH_3 , trimethyl amine,

- $(\text{CH}_3)_3\text{N}=\text{O}$ - excretory material

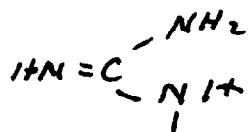
- $(\text{CH}_3)_4\text{N}-\text{OH}$ - found in jelly fish



- Histidine acid deriv.

guanidine

- ~~guanidine~~ deriv.



The purpose of these higher organic compounds is usually very much the same different organisms.

~~E~~

Morphology is a representation of chemical structures.

"Recapitulation theory"

- Holds from chemical point of view of embryo
- first excretes NH_3 , then later the more complex ^{comp'd} urea etc.

Understanding of life best understood thru study of biophysical + biochemical processes of organism.

First undertake the most basic + fundamental processes - this in all

1. Obtaining of energy
 - oxidation, dehydrogenation
2. Utilization of energy,
 - maintaining of order
 - transformation by way of synthesis
3. Control + transmission of these signals, distinct synthetic processes.
 - N metabolism + synthesis

Biological processes can be attacked from a chemical view point.

1/9/41) General Reviews :-

Oppenheimer - Handbuch . 2nd Ed. Vol II p 443 -

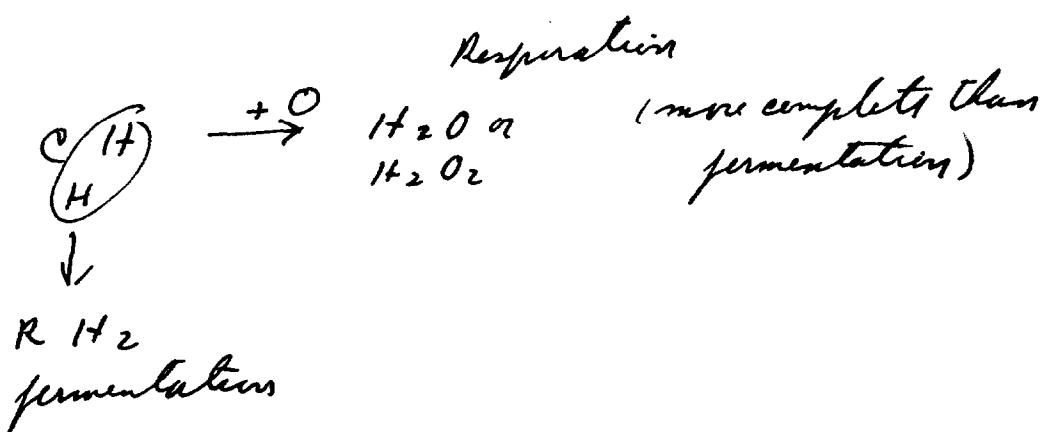
Newberg - J. Bact., 28, 461 (34)

Harden - Alcoholic Fermentation
chapter on Mechanism .

2 ways of oxidation for production of energy .

(1) - with oxygen - respiration

(2) - without oxygen - fermentation



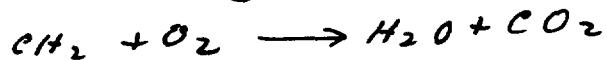
Respiration is much more efficient manner of obtaining energy than fermentation

The first mechanism for production of energy was probably anaerobic (in sea water)

Cite bacteria as example

- Anaerobic organisms
- Facultative anaerobic organisms
- Those preferring aerobic mechanism but can live in anaerobic conditions (yeast).
- Aerobic organisms such as molds.

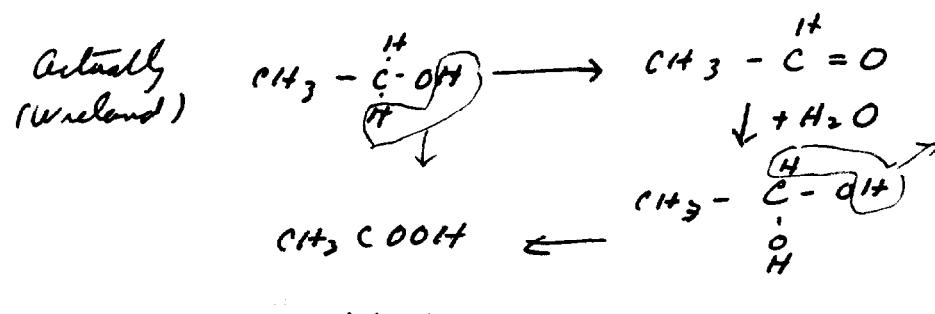
B. coli - aerobically



Glucose anaerobic, nothing

but Glucose anaerobic $\xrightarrow{NaNO_3}$ can carry out anaerobic ferment.

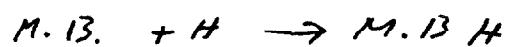
Acetic acid Bact.



(OVB12)

O_2 not necessary to accept 2 H first removed from CH_3OH reduction of H_3 + then

It is essentially an dehydrogenation rather than oxidation since Methylens blue will accept the H's in this bacterial oxidation of CH_3OH to acetic acid (Wieland)

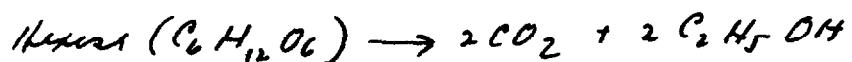


Specialization was little possible until respiratory oxidation mechanisms replaced fermentation mechanism (in scale of evolution)

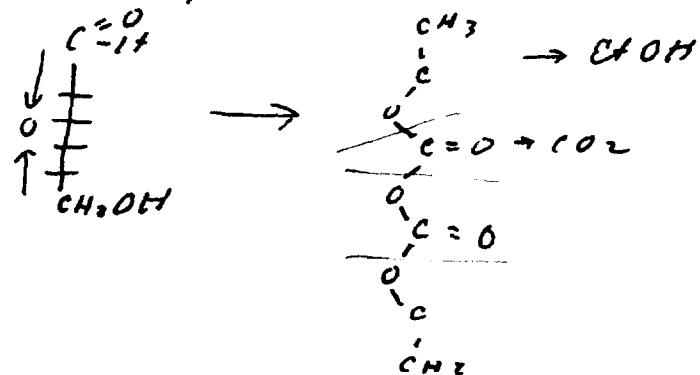
Best to study oxidative or fermentative mechanisms in one celled organisms.

Mechanisms of anaerobic fermentations

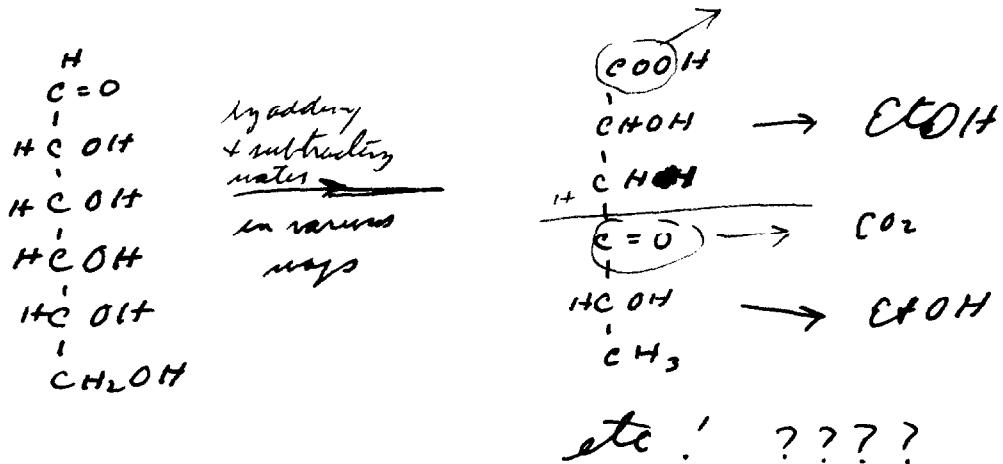
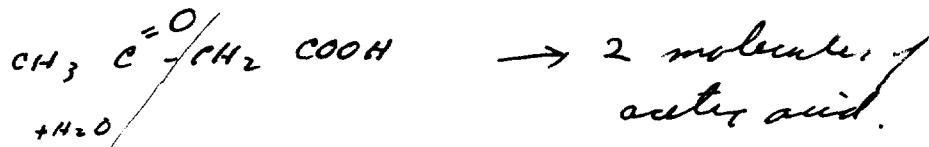
(1) - Alcoholic fermentation



Fund scheme for this reaction :- Raeder 1870



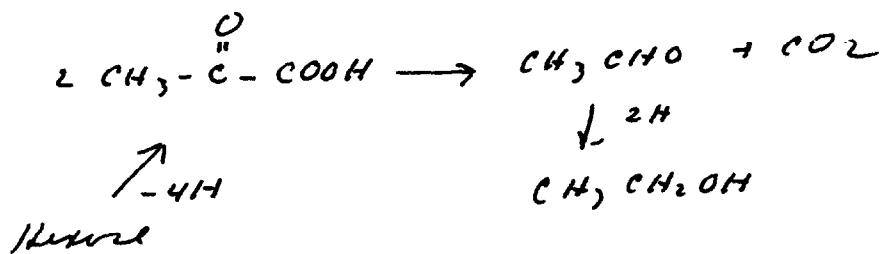
Another scheme :-



Newberg 1914 - established chemical basis
of alcoholic fermentation

1902 - Magnus Levy - $\text{CH}_3, \text{CH}_2\text{O}$ bases for ferment.

1910 - Postyschenko pyruvate " " "

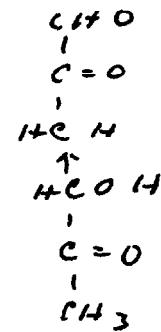


These schemes don't explain presence of glycerol, H_2O_2 etc found in alcoholic fermentation

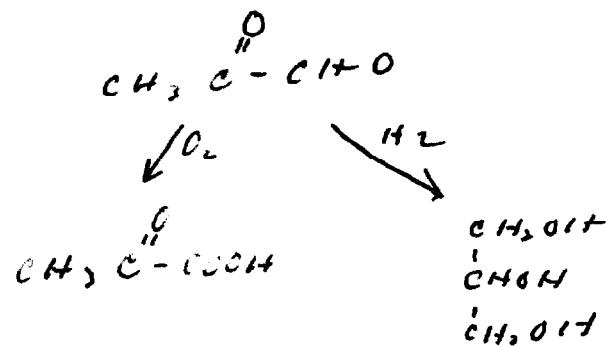
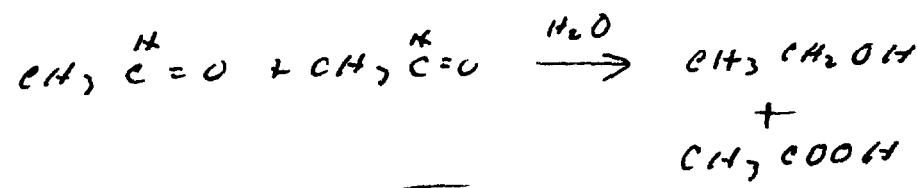
Newberg 1914 - accepted pyruvic acid as an intermediate in alcoholic fermentation

- Found $\text{CH}_3\overset{\text{O}}{\underset{\parallel}{\text{C}}}\text{-CHO}$ intermediate

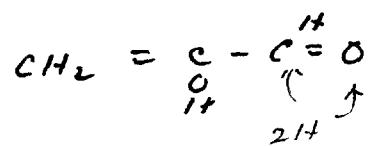
Mass yeast culture \rightarrow methyl glyoxal
Ferment \rightarrow lactic acid.
(glyoxalase)



Newberg also considered possibility of
Cannizaro reaction :-

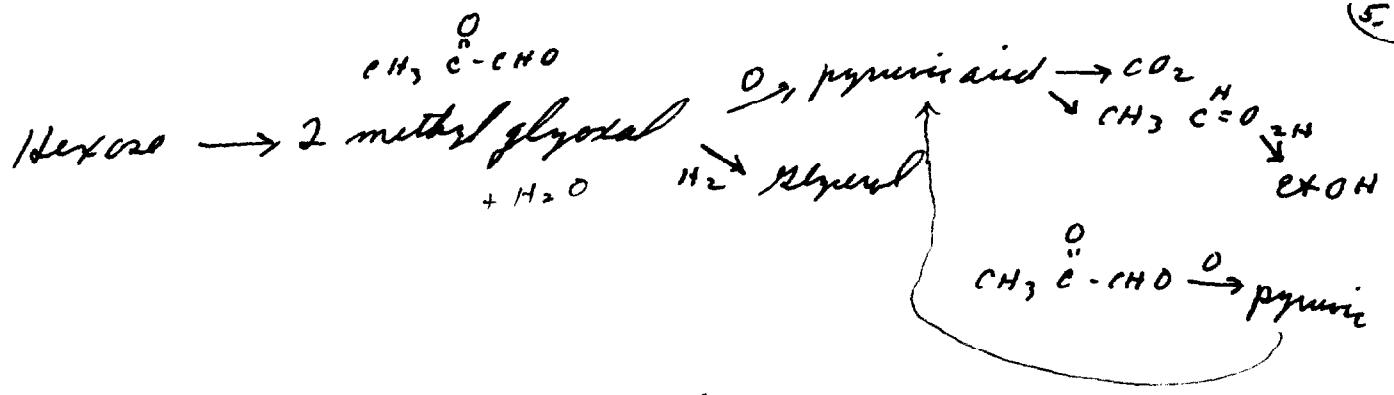


comes to equilibrium with ~~standard~~ to enolic form.



Dr Newberg formulated as follows the
lactic fermentation :-

(next page)



Remove acetaldehydes with NaHSO_3 - results in an accumulation of glycerol.



Can also remove CH_3CHO by adsorption by ethanol.



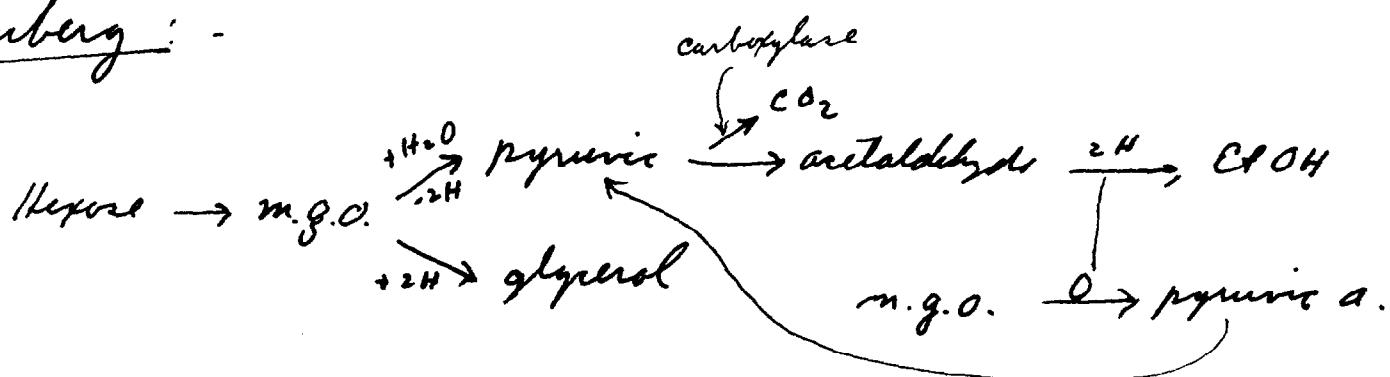
1/14/40

Harden - (Read libr.)

Stephenson - Proc. Met. 77-87

Oppenheimer - Stein - 244-249

Newberg: -



Carboxylase enzyme

Glyoxalase "m.g.o." \rightarrow lactic acid

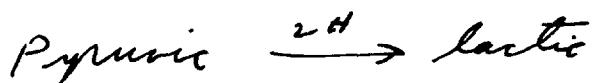
Hep. \rightarrow m.g. o $\xrightarrow{\text{glutathione}}$ lactic a.

Schumann : - glutathione necessary as co-enzyme

Where does lactic acid come from in muscle? :-



Meyerhof proposed :-



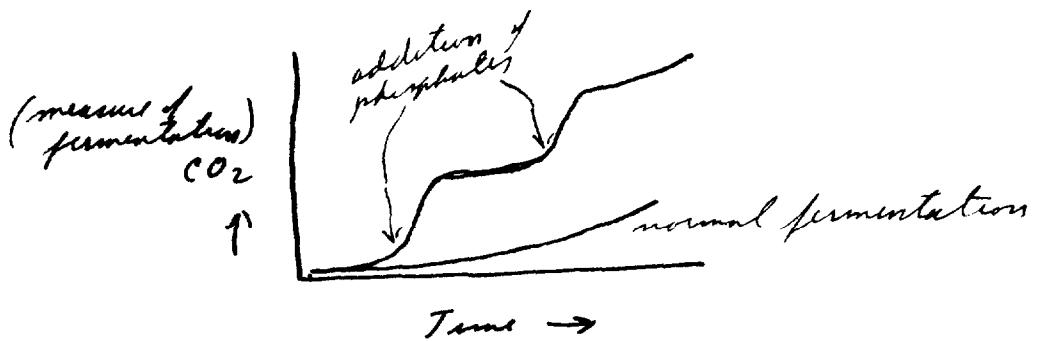
\therefore picture is : - (in muscle)



— — —

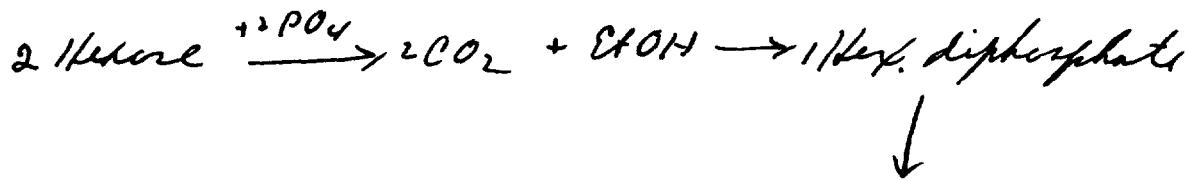
Relation of Phosphates to alcoholic fermentation:-

Harden & Young : -



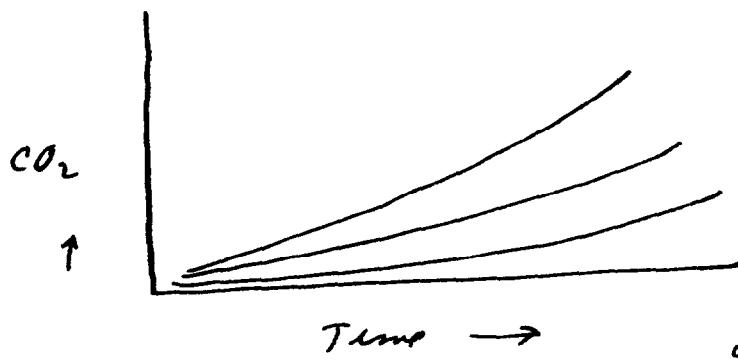
Found that before phosphate formed.

(6)



Coenzyme of co-zymase in normal serum :-

Harden :-

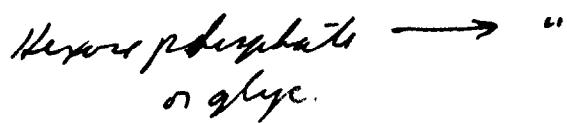
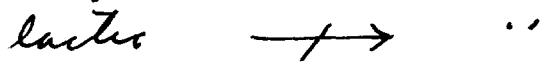


Drop in activity
due to inactivation
of co-zymase.

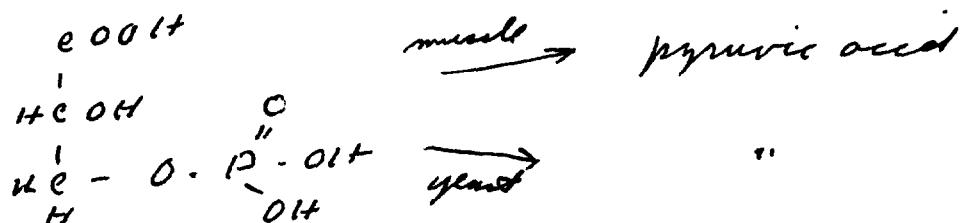
Found that normal
activity restored by
introduction of normal serum
which has co-zymase present.

Back to muscle metabolism :-

Meyerhof : - postulated & proved intermediate
nature of pyruvate in muscle metabolism.

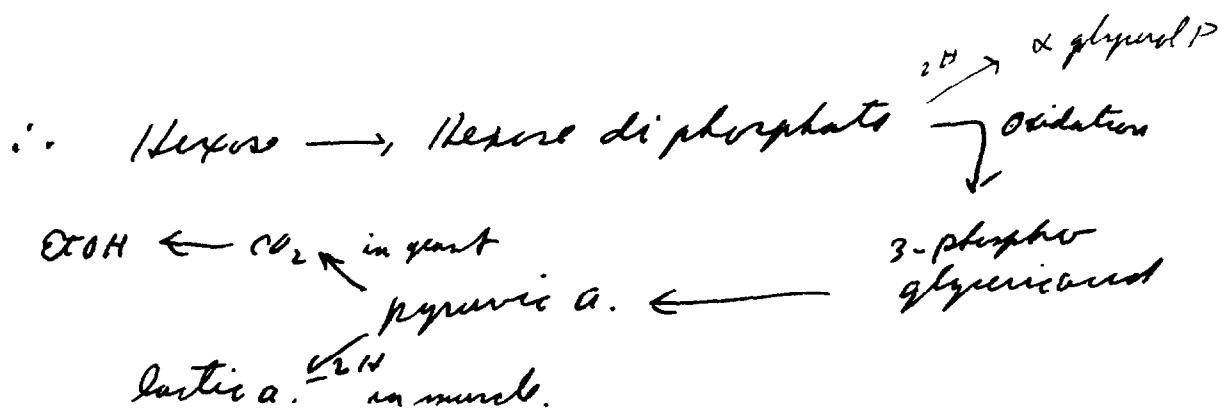


Nelson :- isolated 3-P-glyceric acid



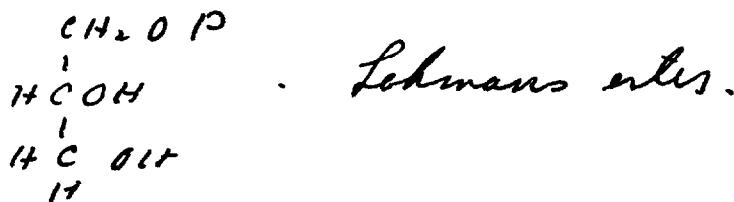
Johnson : - isolated from muscle. Na^+ with

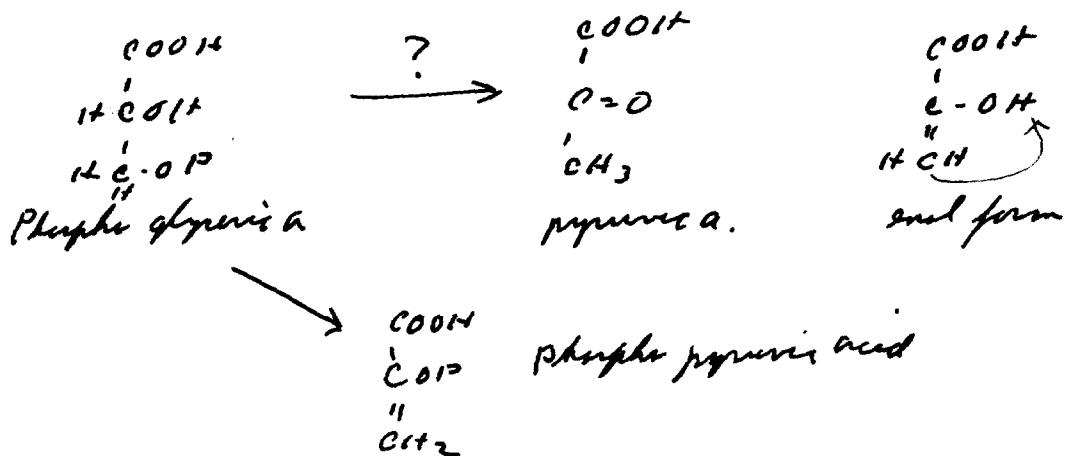
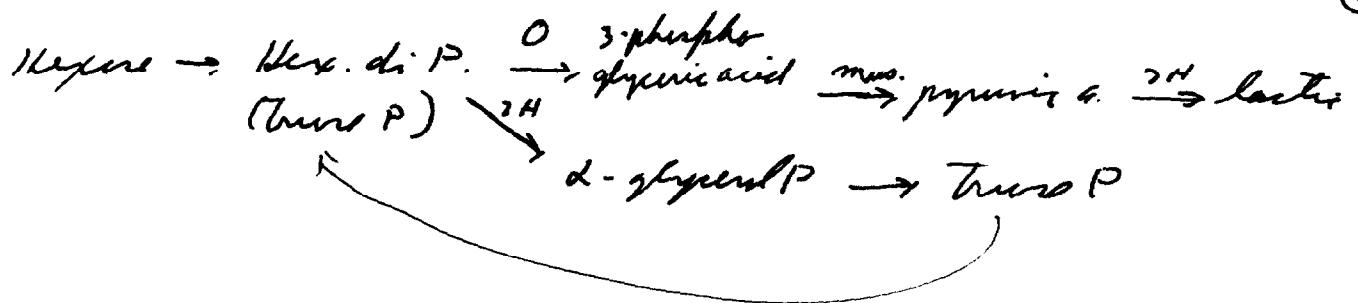
- also a mixture contg 3-Phospho-
glyceric acid.



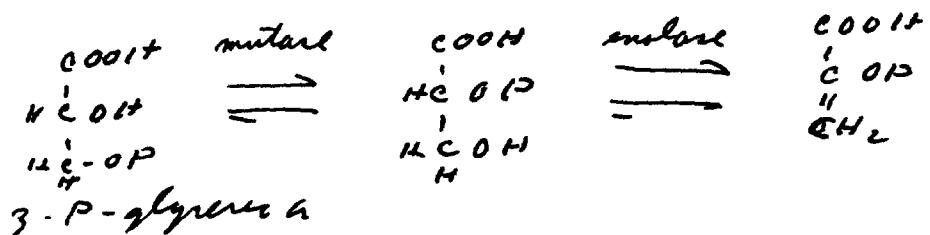
Searched for reduced product upon oxidation of
threonine di-phosphate to 3-P-glyceraldehyde:-

- found to be α - glycerol P.



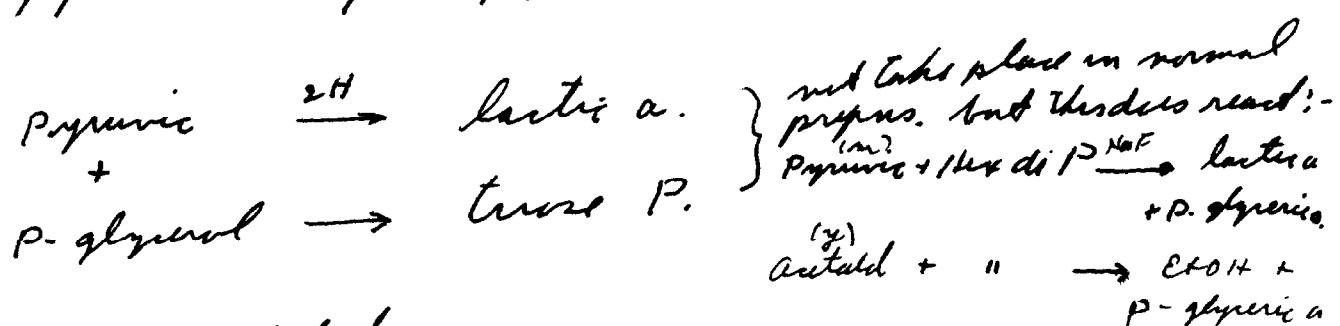


Point that in enzyme system:-

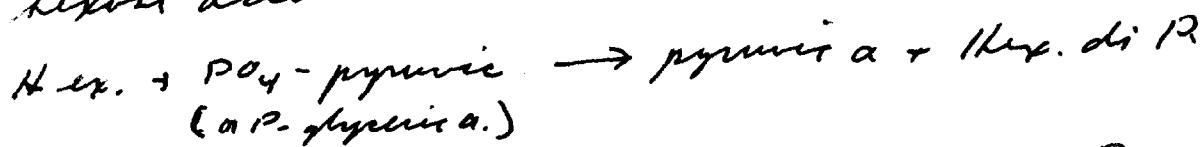


Using P-pyruvic acid in fermentation process:-

~~P~~ $\xrightarrow{\text{in}}$ P-pyruvic a. $\not\rightarrow$ pyruvic acid

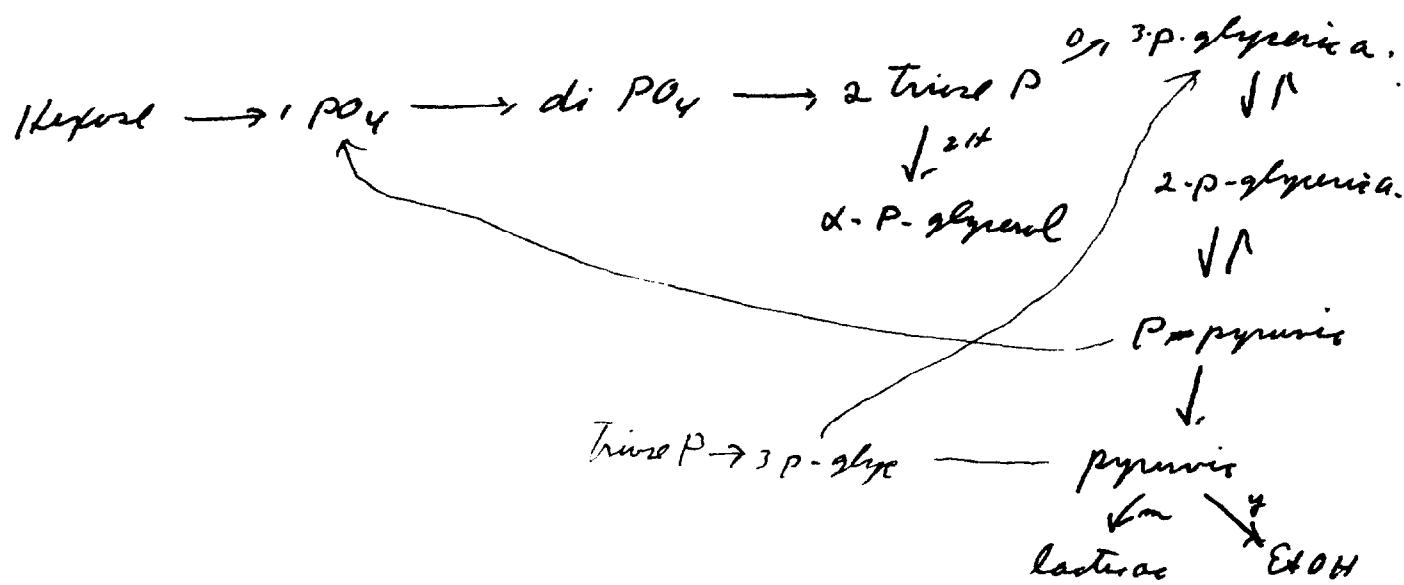


If hexose added:-

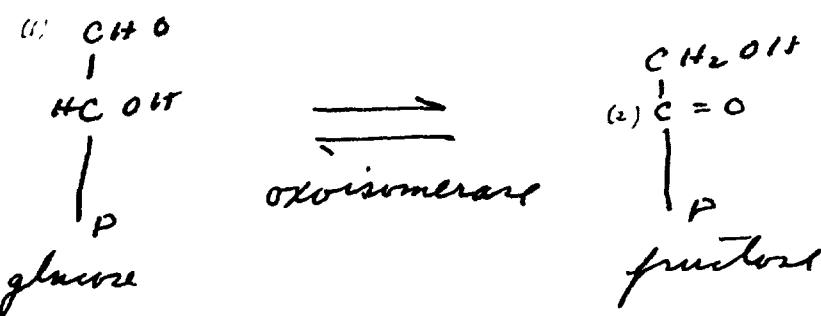
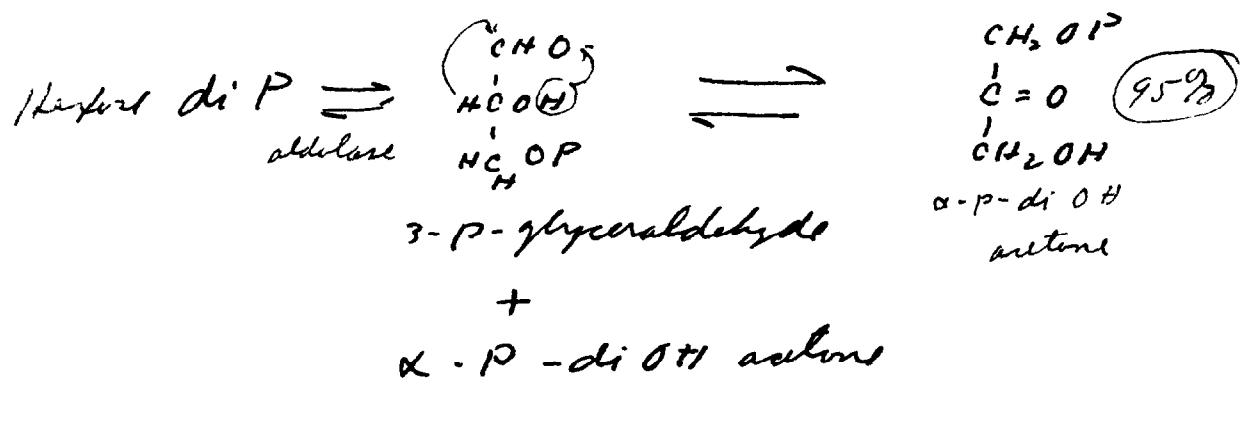
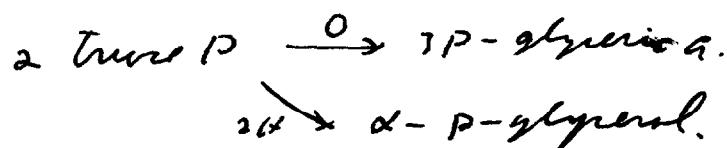


Proves that PO_4 transferred readily to Hex di P.

Final scheme in either yeast or muscle :-



Iodoacetic acid inhibits reaction:-



1/16/40

(8.)

Coenzymes (Review)

Raumann & Stern

Physiol. Rev. (1939) p 353

Co-enz - alcoholic ferm.

Stephenson - Recd. Metab

- muscle & energetics

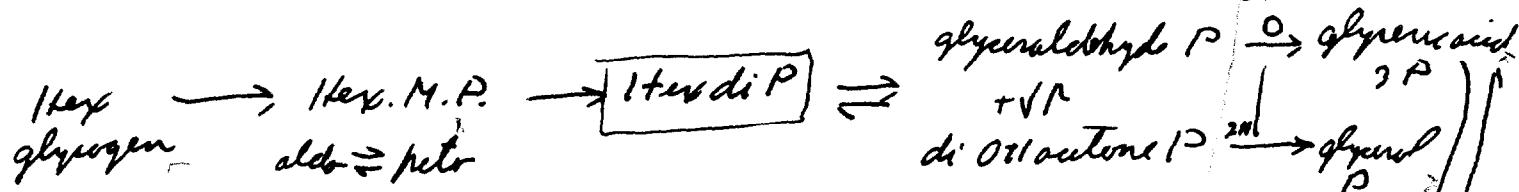
Perspect. Biochem - Needham

Review - fermentation as metab.

Oppenheimer & Stern

Recd. Oxid p 241

I A. 16. 1



NH₄ F
etc.

2 glyceric P

**Alcohol
fatty a.**

I A. 16. 1

2 glyceric P

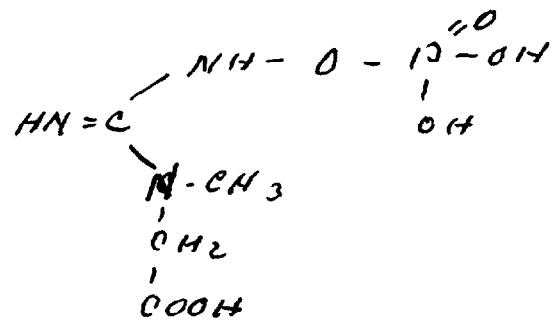
11

CO₂ + acetald. \leftarrow P-pyruvic
pyruvic \leftarrow

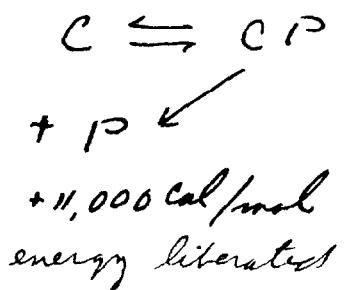
3P-glycerate \xrightarrow{O} + glyceral P

In muscular contraction - energy is supplied by production of lactic acid.

Eyeloff - 1927 - discovered phosphogen or phosphocreatine in muscle



H_3PO_4 is split off during muscular contraction

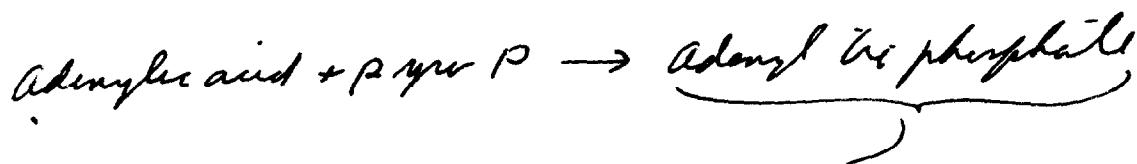
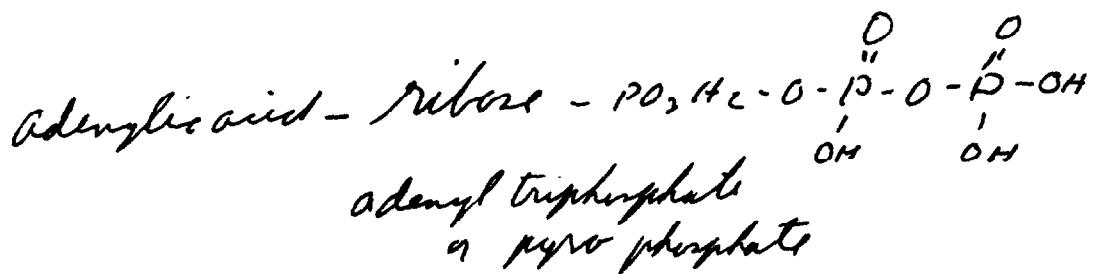
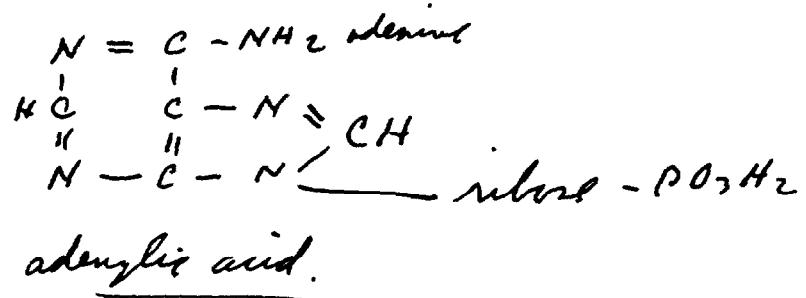


Creatine + P_i -pyruvate → no reaction

Creatine phosphate + Hex → no reaction

Coenzyme of phosphorylation & dephosphorylation
is necessary.

Adenylic acid was found to be this co-enzyme

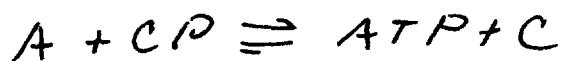
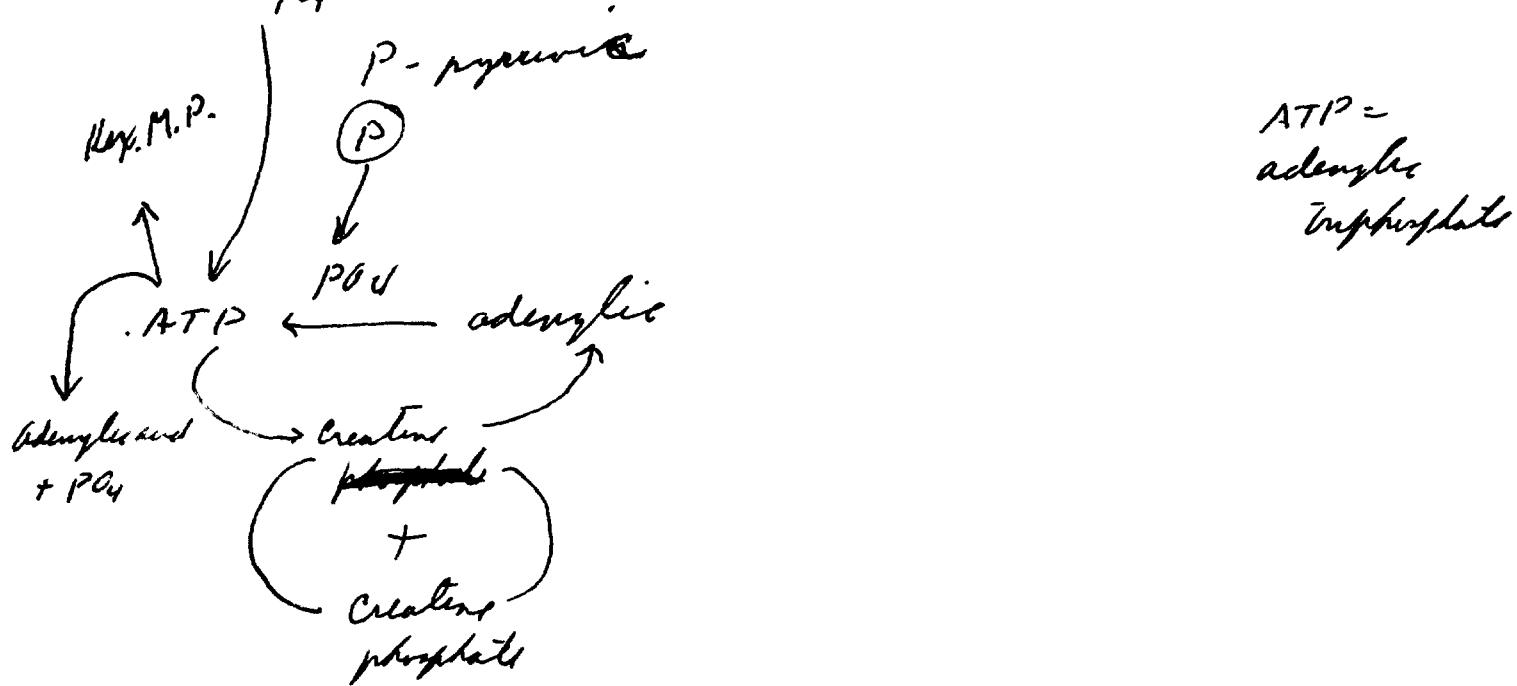


This compound does give
phosphate to glycogen or hexose



Steps of phosphate transfer scheme :-

phosphate (inorganic) from reaction glyceraldehyde $\xrightarrow{3P}$ glyceral P



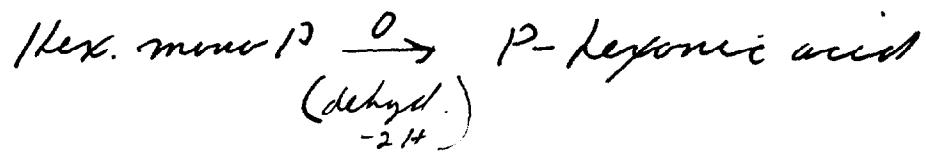
Is in equilibrium thermodynamically

Creatine phosphate is store house of Phosphate
in phosphorylation mechanism

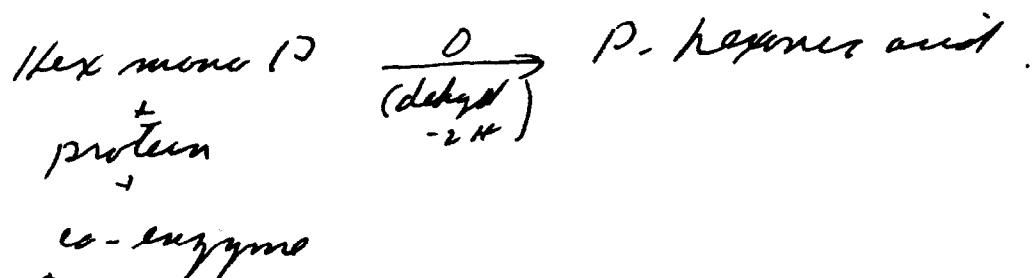
Co-phosphorylase

Co-glyceral.

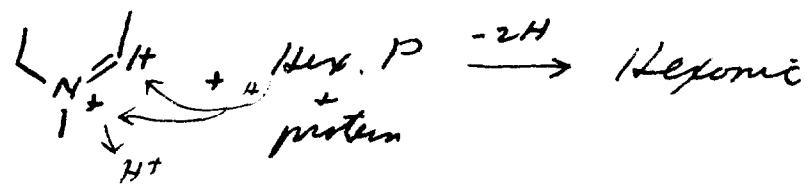
Warburg :-



To make this reaction possible :-



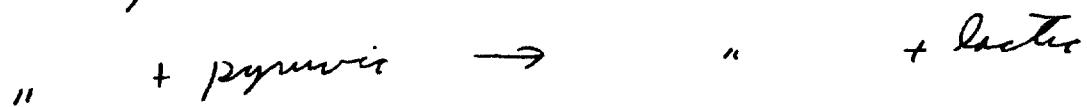
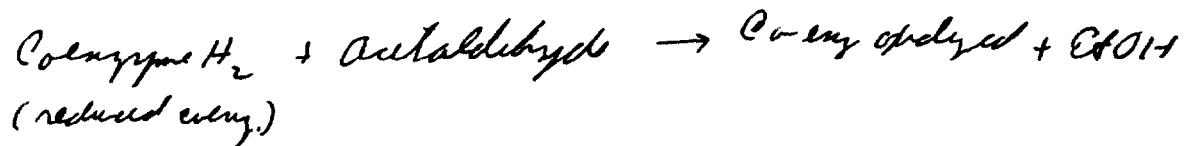
This coenzyme was:- adenosine - ribose - phosphate
 ribose - phosphate - phosphate
 -CO-NH₂
 (amide of mustard acid)



This is known as Warburg's coenzyme II

Coenzyme I (cozymase) = Di-P nucleotide

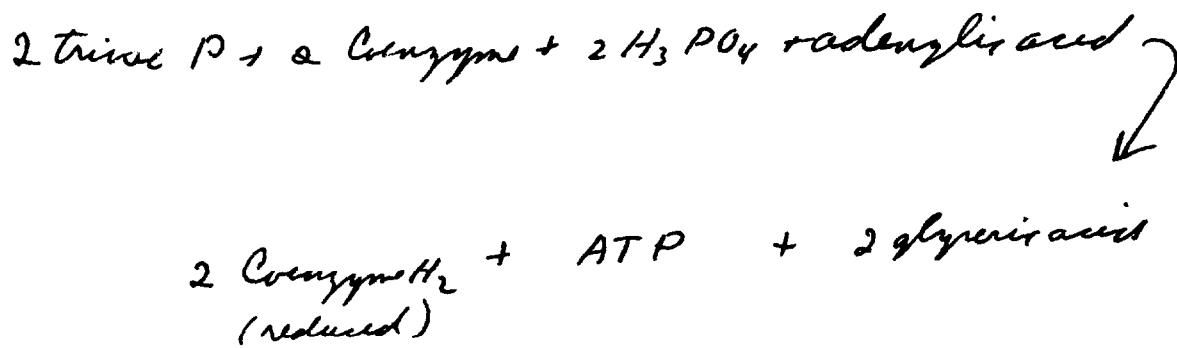
Coenzyme I + protein A = alcohol dehydrogenase



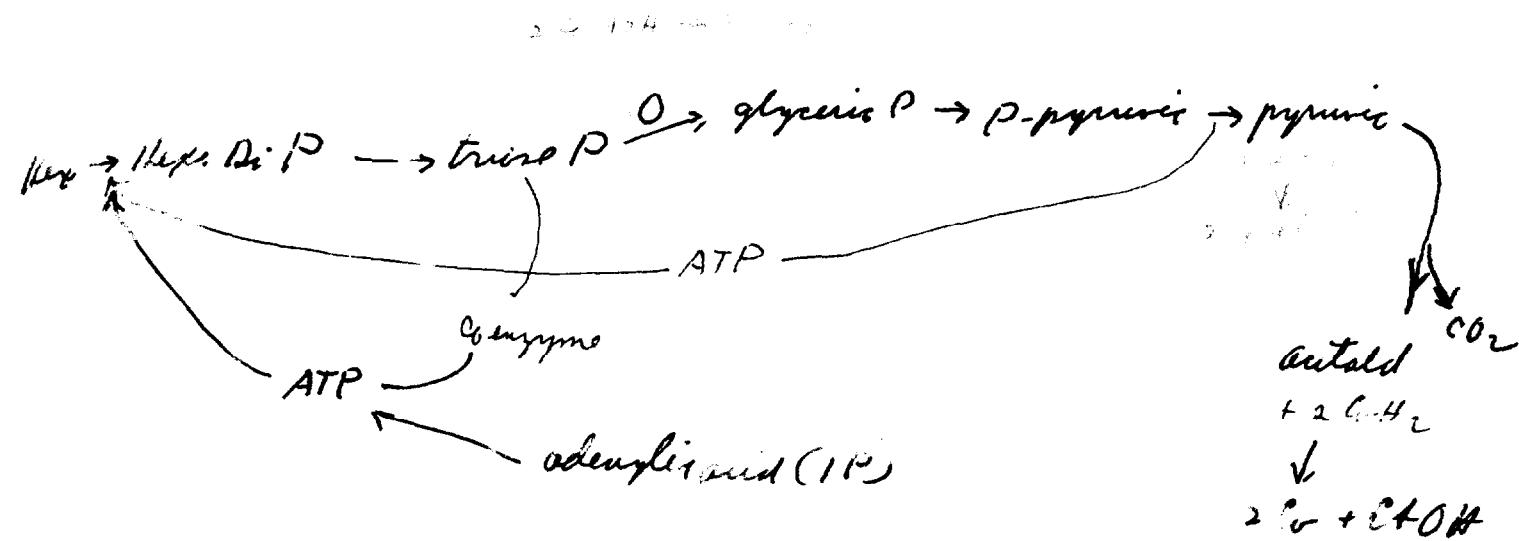
These reactions take place stoichiometrically

—o—

Needham & Mayrby : -



Complete scheme of decomps of Hex ADP. : -

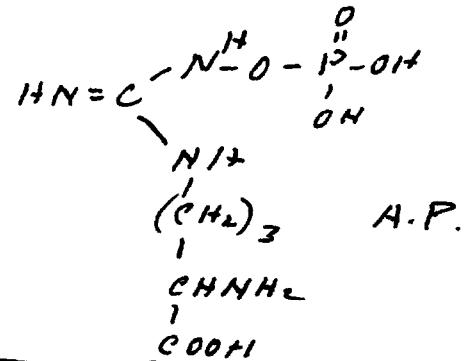
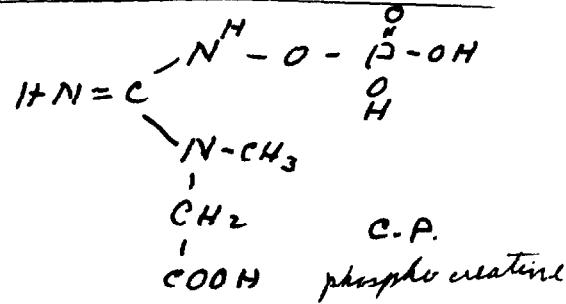


1/21/41

Stephenson pp 87-110

Kluyver - Chem. Act. Microorg.

Baldwin - p 66.



	AP	CP	AP → ATP / ADP + ATP
Protozoa	-	-	
Porifera	-	-	
Coelenterata	+?	-?	
Annelida	+	-	
Arthropoda	+ (enz)	-	+
Mollusca	+	-	+
Echinodermata - Asterioidea (l-noto)	+	-	
Holothuridea -	+ (enz)	- (no)	
Echinoidea	-	+ (enz) ±	+
Chordata			
Pisces " - Tunicata	+	-	
Enteropneusta ^(l) a-noto	+	+	
Cephalochordata	-	+	
Vertebrates	- (no)	+ (enz)	+

Phosphorylation - review

3 ways -

- (1) Inorganic esterification of glycogen
- (2) Glycogen - AA system
- (3) Breakdown of AA.

Co-enzymes

Dif. between $\gamma + m$

γ has two carboxylate

m has lactate dehydrogenase (?)

Phosphate cycles: - how valid are they?

- Hexose P isolated in plants

- Triose P " " "

- Speed up fermentation by addition of inorganic PO_4

- Essential nature of AA system of co-enz. function

- Inorg. phosphate decrease during fermentation

- Phosphagen cycles

Newberg's schemes - supported by

- glyoxalase activity
- reactivity of glutathione

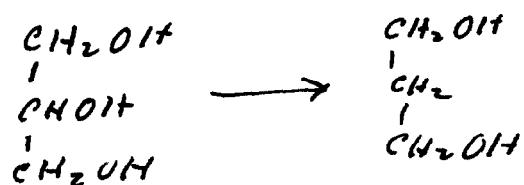
Therefore - 2 forms or courses of fermentation

- (1) - Phosphorylated systems
 - (2) - The one with methyl glycal as intermediates (Newberg).
-

Evolution of mechanisms :-

- first without enzymes
 - more intermediates + enzymes
 - several sources of PO_4 for phosphorylation
-

Bacteriaceae - There is one species which can ferment glycerol.



B. coli :- fermentations of mammal

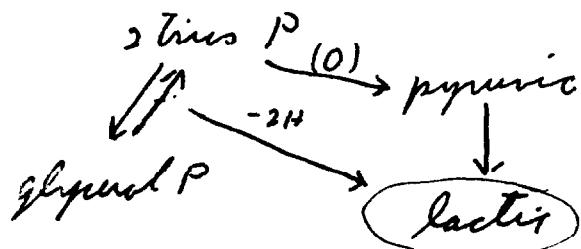
mammal glycerol gluconic acid

HAc	7	16	48	50
CTOH	27	16	2.6	1.0

Correlations to ox + red. dependency
open to debate

Simple bacterial fermentation :-

Hex P(di)

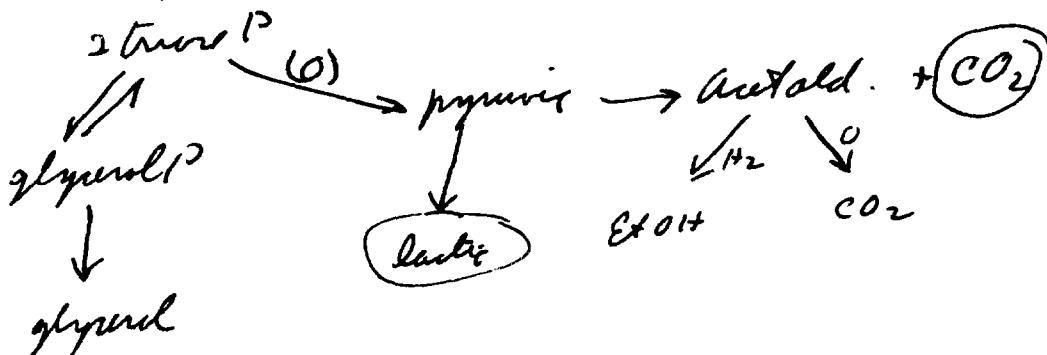


lactate

More complex system :-

EtOH, HAc, CO₂, lactic a. glycerol (end products)
 1 : 1 : 1 80%

Hex P (di)



B. coli Fermentation :-

Lactic acid - 50%

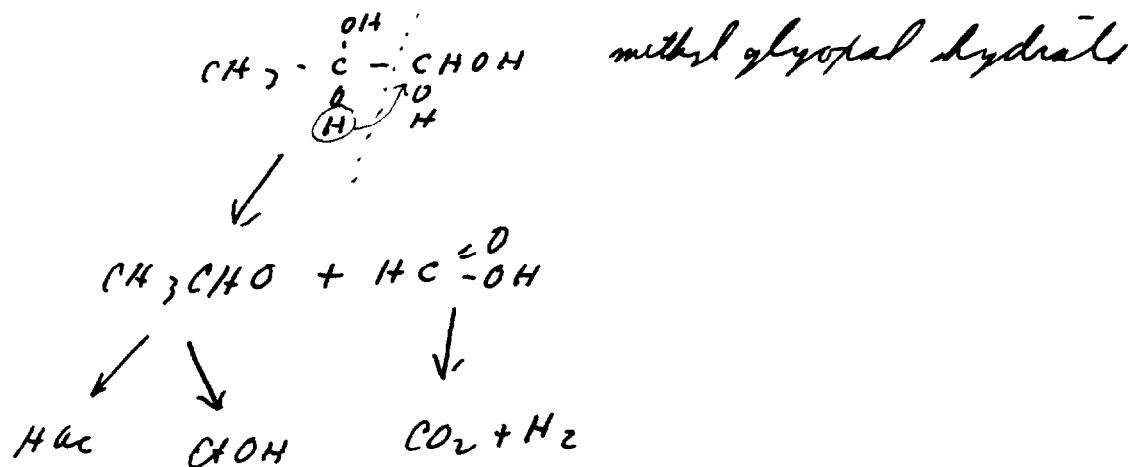
HAc ! → from acetalddehyde
 EtOH ; → from lactic acid

H₂ * → from former acid
 CO₂ ; → from former acid

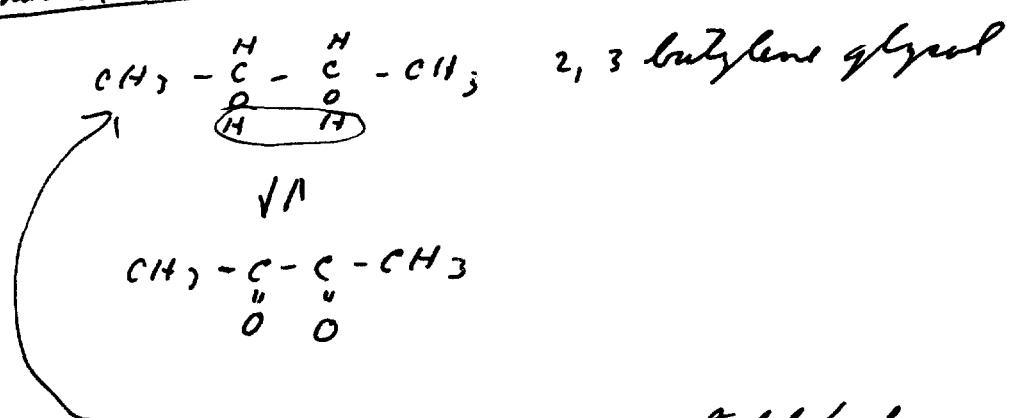
(next page)

- factors a. formed by traditional methods
 - but the other two phosphate molecule goes as follows : -

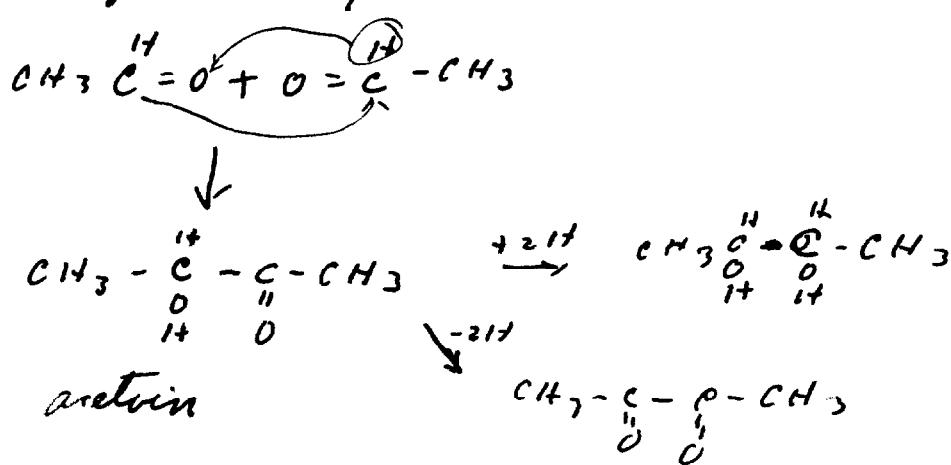
(13.)

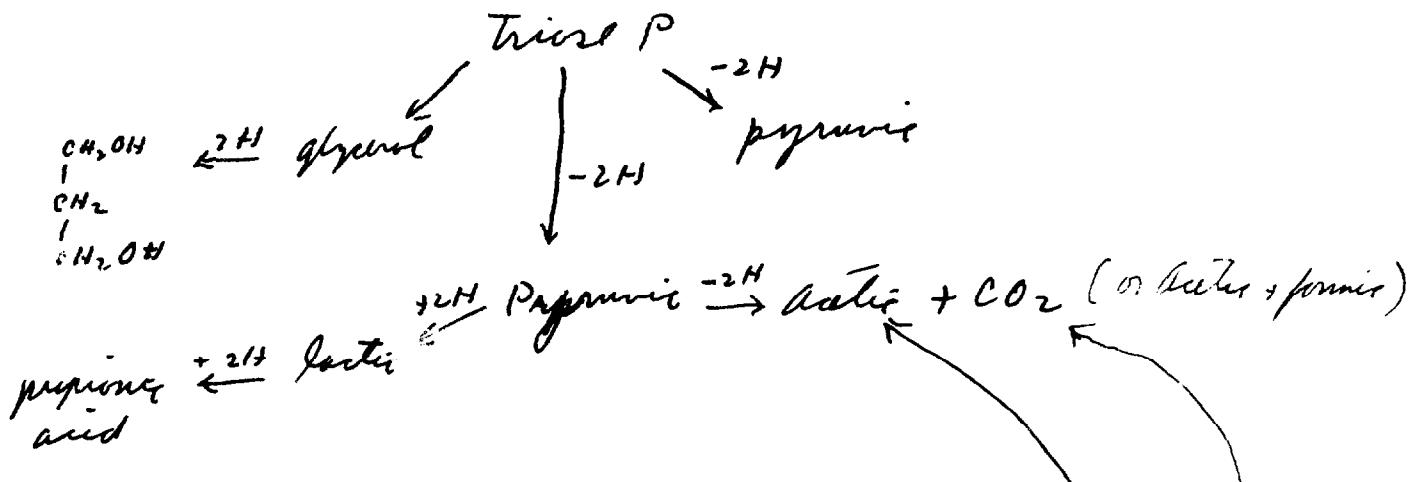


Another export breakdown :-

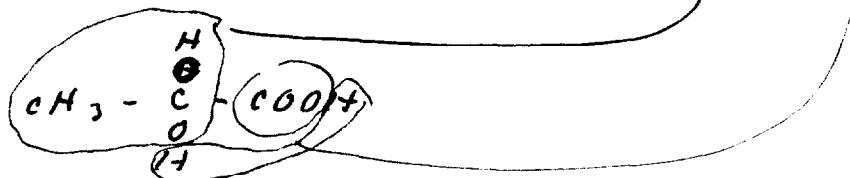


This comes from cond. of acetaldehyde

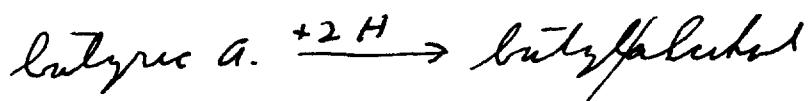




Another reaction to be considered : -

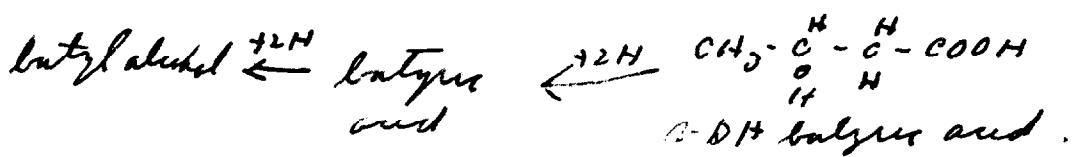
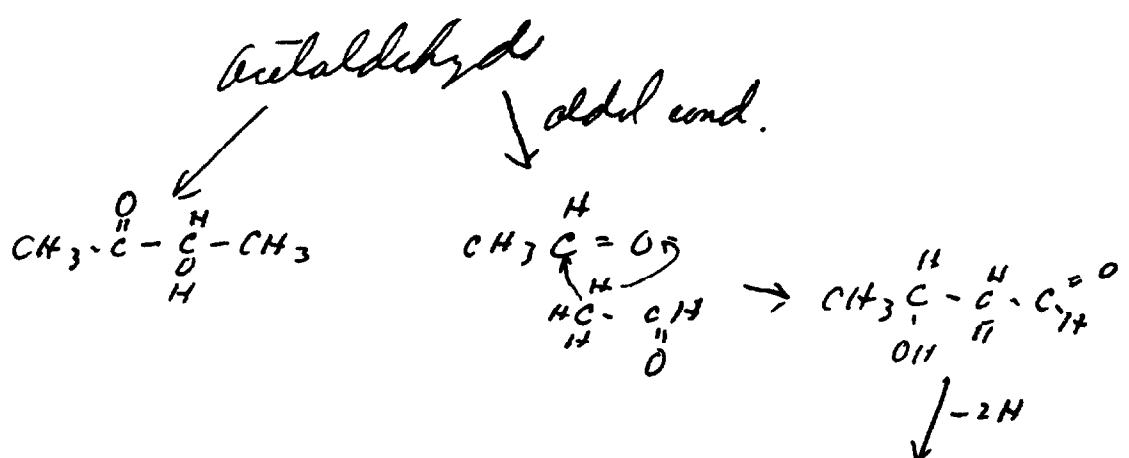


In butyric acid fermentation : -



— o —

Condensation reactions : - (butyl alc. formation)



(1/23/41)

(14)

Stephenson p 114 (Sorbose lard.)

Annu. Rev. Biochem. (40) p 29-33

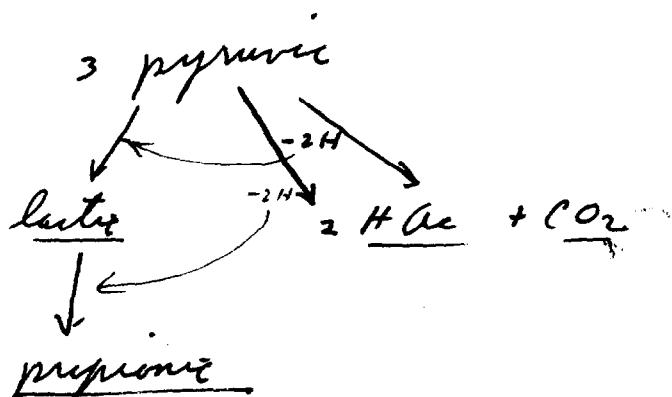
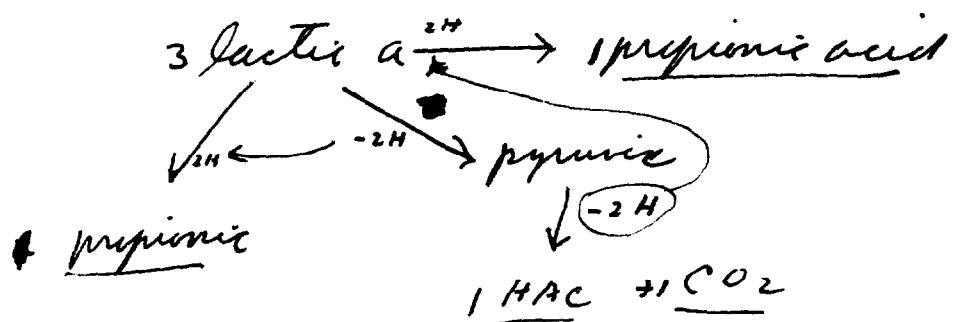
(reactions pyruvic acid)

Biology. Oxid. p. 249-254

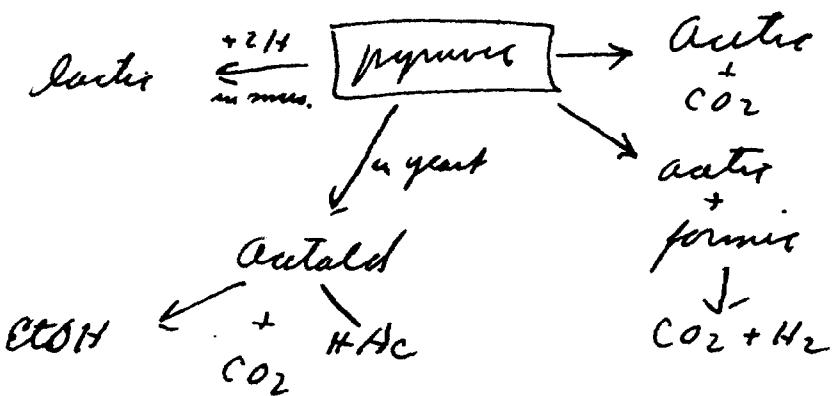
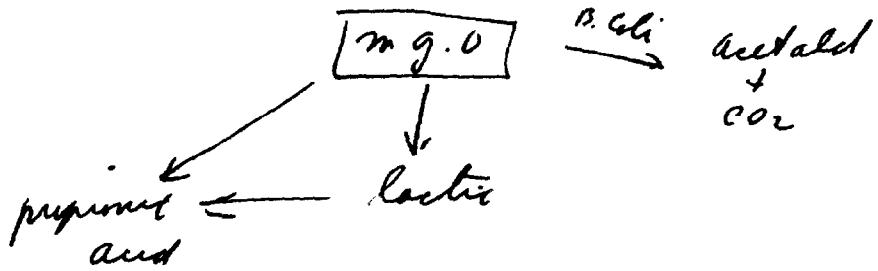
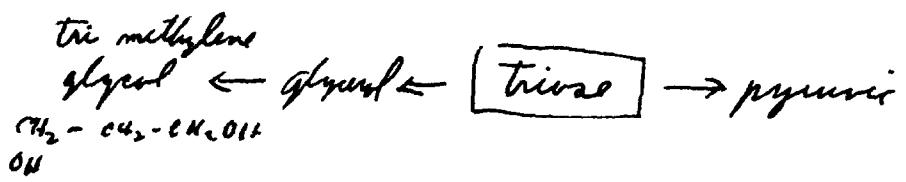
(general oxidative mech.)

Significance of transitions between two phosphates
(arginine + creatine)

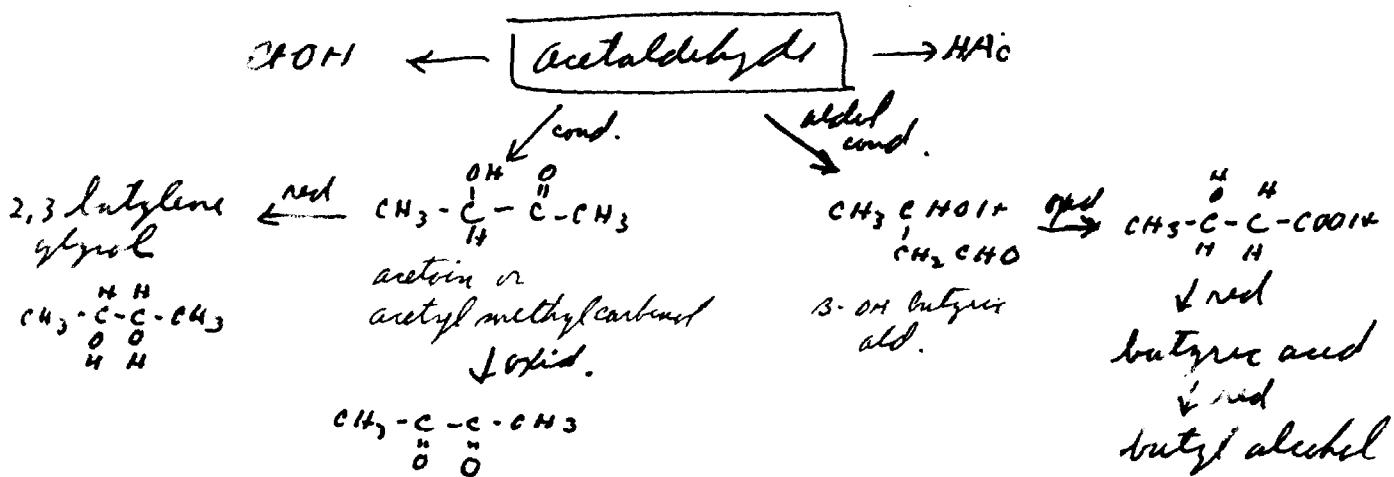
Propionic Acid bacteria :-



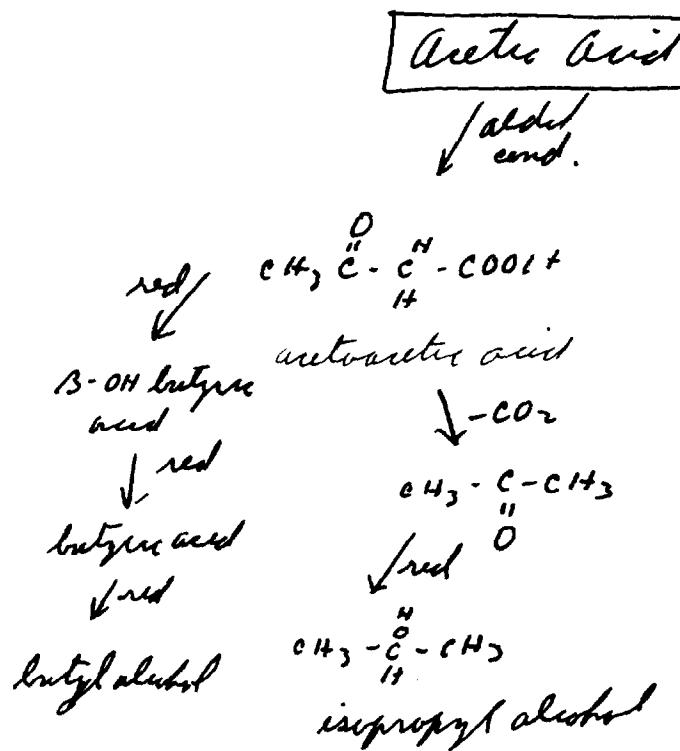
Anaerobic fermentation :-



Possible reactions of Acetaldehyde :-

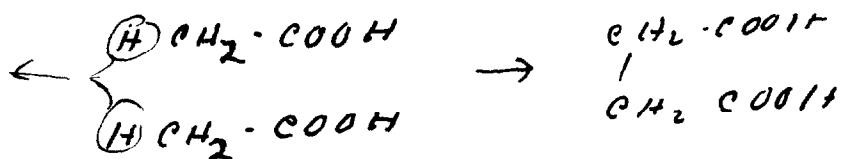


Possible reactions of acetoin : - (anaerobic bacterial fermentation) (15th)



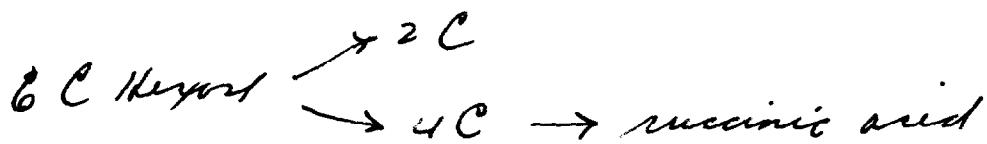
Several products which can't be explained by schemes developed from these :-

Succinic acid is one :-



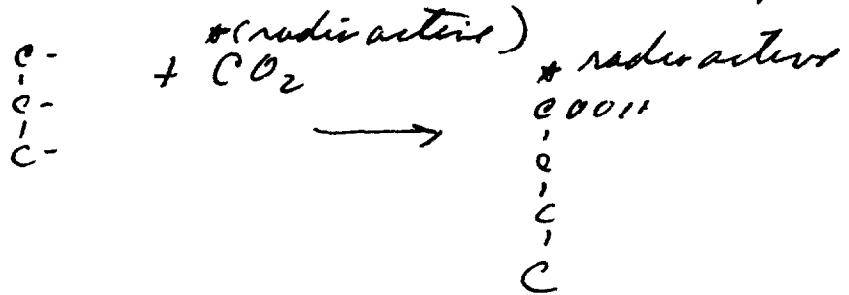
This mech. has not been proven

Another explanation :- not proven



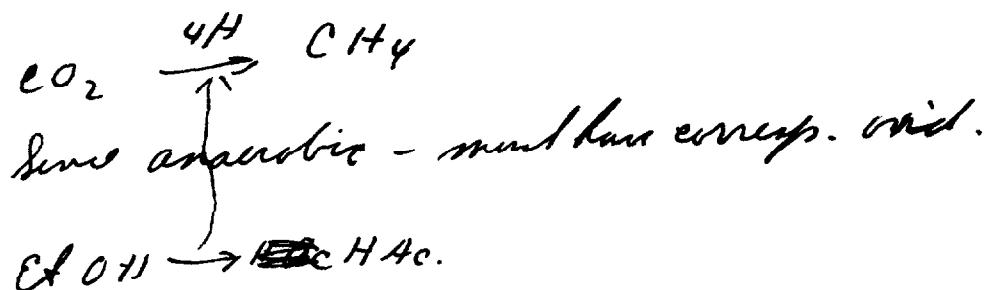
(next page)

More schemes for succinic acid: - just a postulate



Another unexplainable product - Methane!

Possible scheme

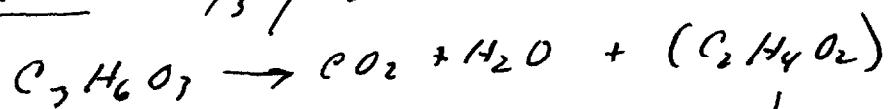


Ratyl → Ratylic → acetic

— —

In muscle $\frac{1}{3}$ of lactic acid formed in muscle contractions is irreversibly & aerobically oxidized to $\text{CO}_2 + \text{H}_2\text{O}$ → releases energy. The other $\frac{2}{3}$ lactic acid is reconverted to glucose + glycogen.

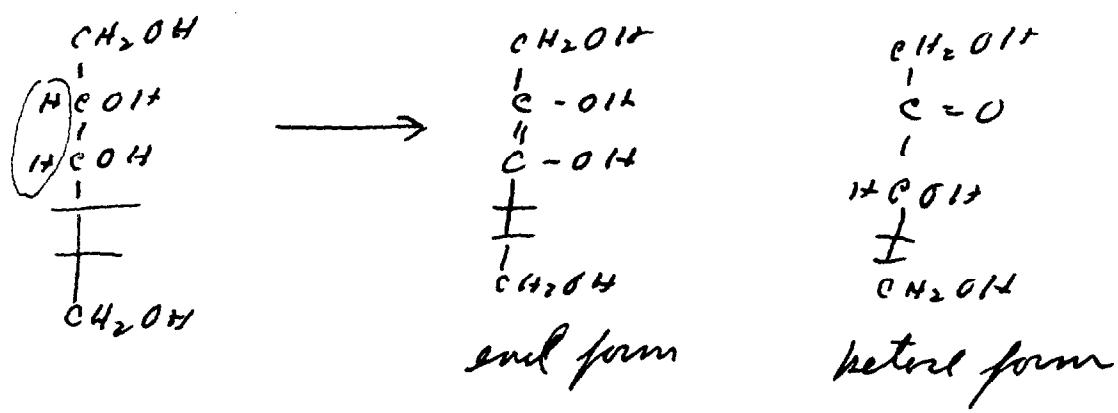
St. Byorghi : - $\frac{1}{3}$ of lactic acid mol is oxidized



not 1 lactic acid mol. out of 3.
↓
glucose, starch etc.

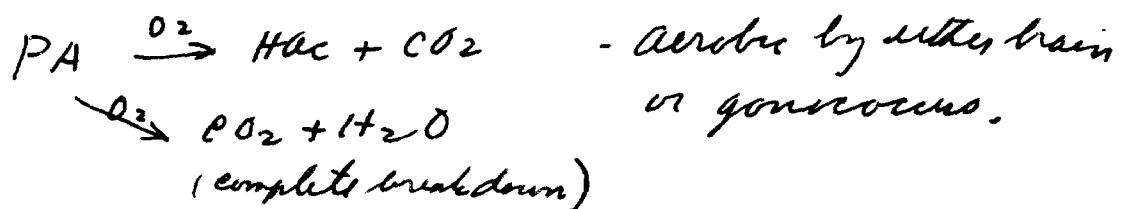
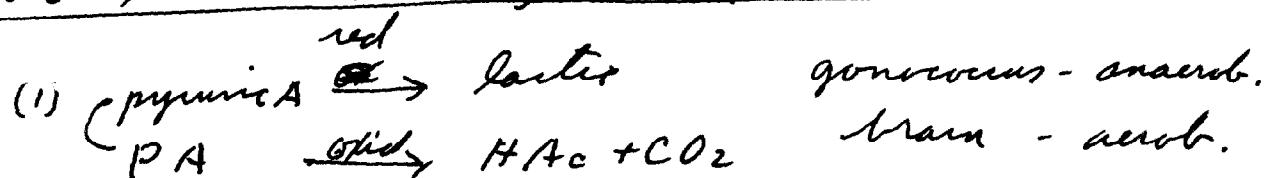
(16)

Atypical Oxid. of Lactic Bacteria :-

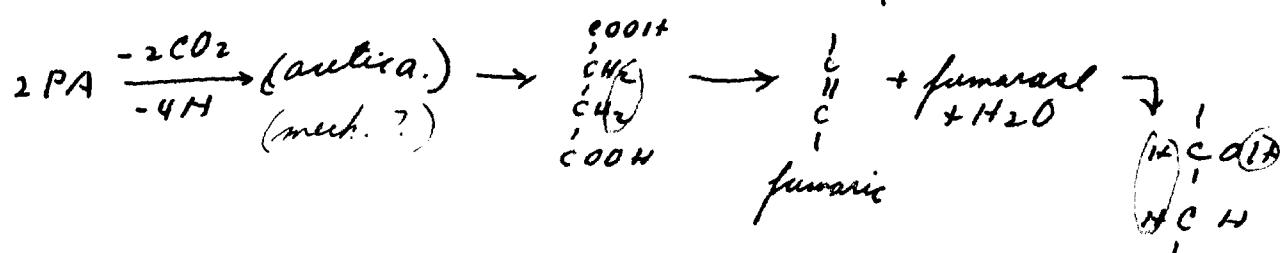


— o —

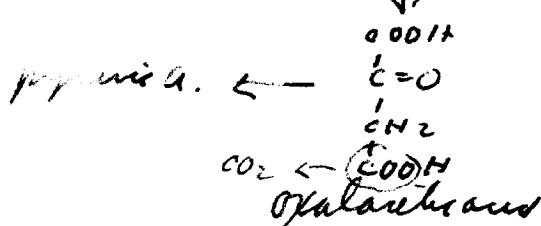
Aerobic Oxidations starting with pyruvic acid :-



Elliott - kidney chopped up. - complete breakdown
of pyruvic acid



cycle goes around: $2 \text{PA} \rightarrow 1 \text{PA} + \text{CO}_2 + \text{H}_2\text{O}$

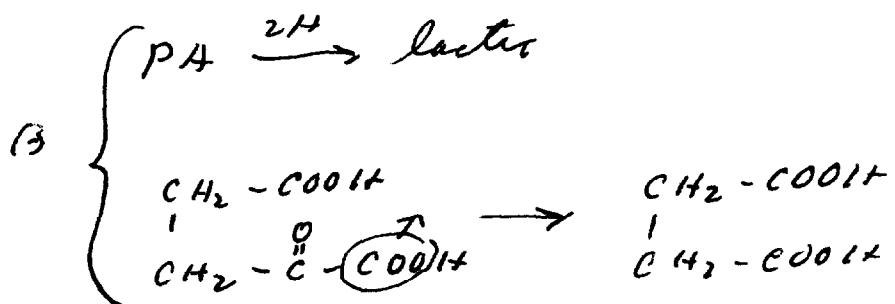
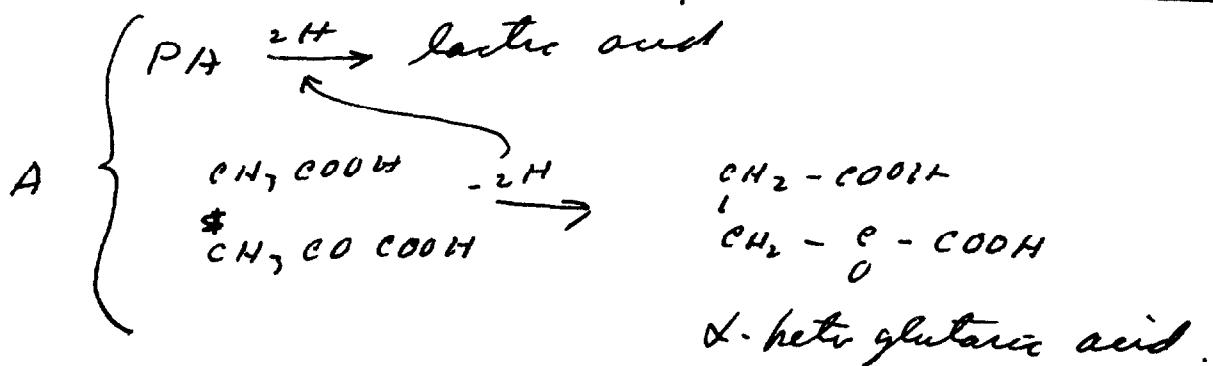


Years! - when food is depleted - shown to be true
 $\text{EtOH} \rightarrow \text{Acet. ald.} \xrightarrow{\text{oxidation}} \text{succinic acid}$
 This fails to
occur in animal tissues

Overall reaction of pyruvic a. to succinic a. does
take place in animal tissues : -



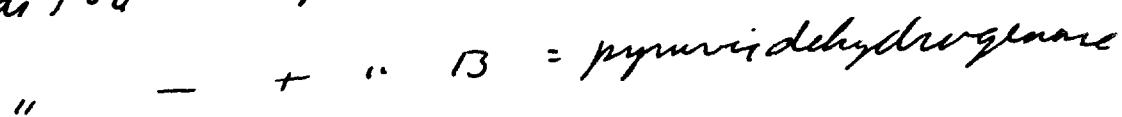
Possible mechanism for prod. succinic acid in muscle:-



1/28/40

17.

Vit. B₁, - di PO₄ is coenzyme of carboxylase

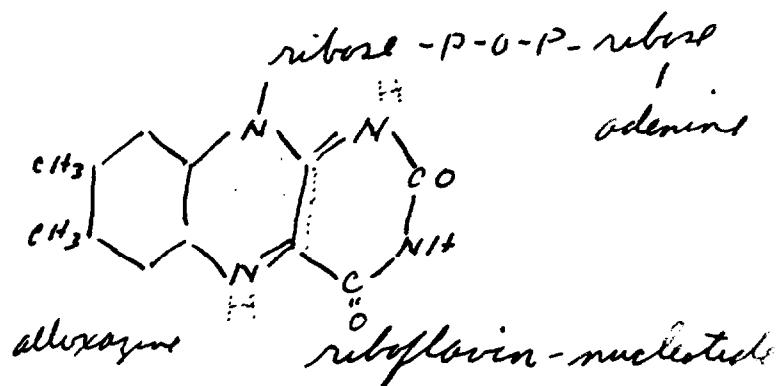
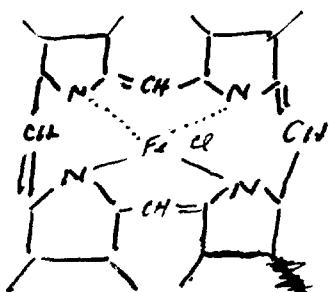
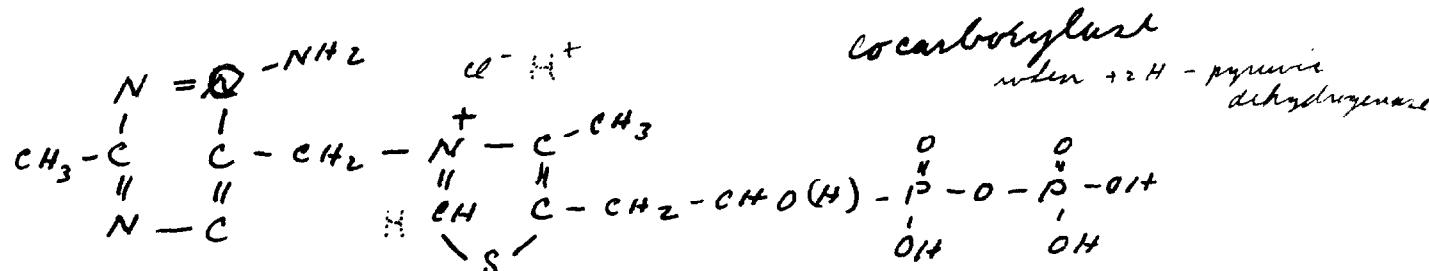


— o —

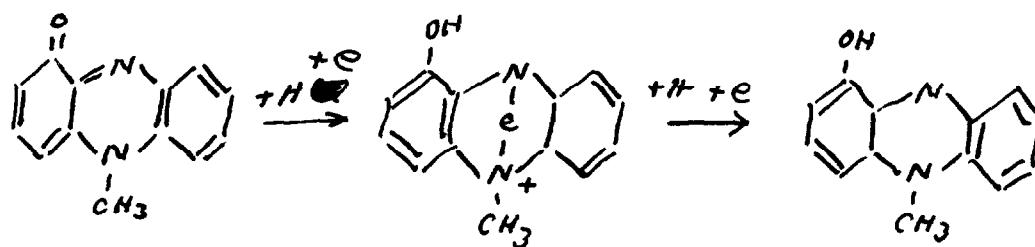
Barron - Physiol Rev '40, p184

Biol Oxid. p 261-276

Annu Rev Biochem '40 p17-28



pyoverdine



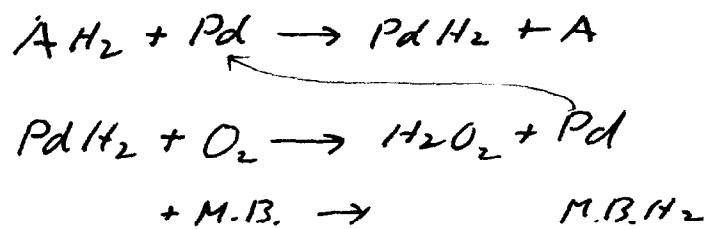
Thiamine or Vit B₁ deficiency - no respiration involving pyruvic acid. This corrected by addn of Vit B₁ to diet.

Chrליך :-

1902 - Enzyme oxidizing aldehydes + reduction of Methylene blue

Wieland - dehydrogenation - activation of Hydrogens.

- Model system :-



This process carried out by all tissues

Thunberg 1925 :-

- marked tissue - anaerobic tissues
no red. of M.B. unless H₂ donor added. If added, dehydrogenase enzymes found to be present

2 types of oxidation enzymes

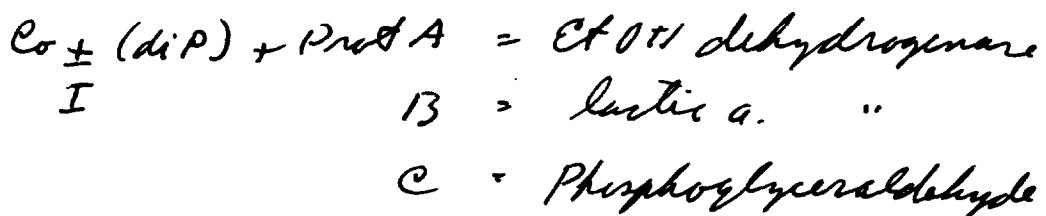
三

1. Oxidases or aerobic dehydrogenases
 2. anaerobic dehydrogenases

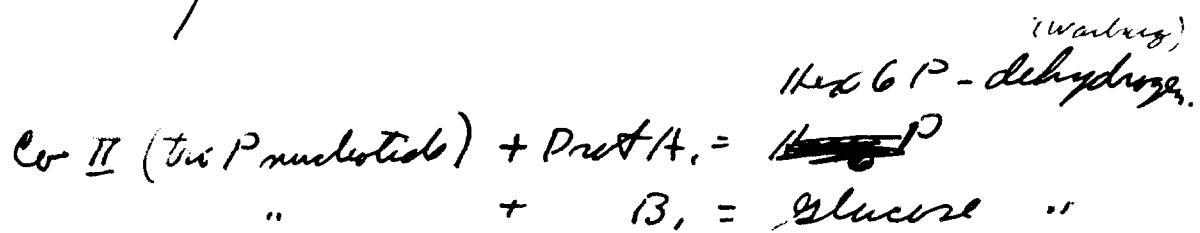
(ii). Oxidases - form H_2O_2 - this oxygen utilizable than peroxidases for further oxidation

Colonyes :-

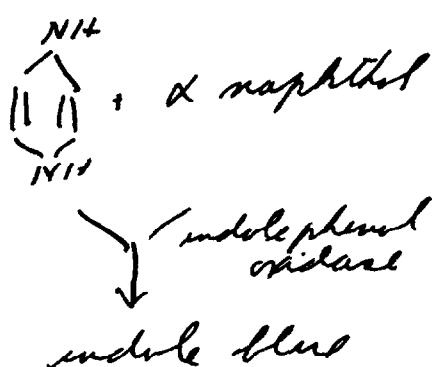
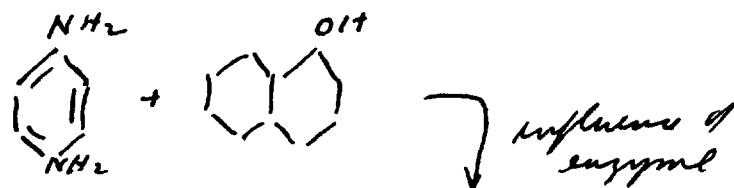
- actually constituents of final enzyme



The protein has effect on specificity
of reaction



Aerobic oxidases : - found in all tissues (almost)
 - tested for by Nadi reagent



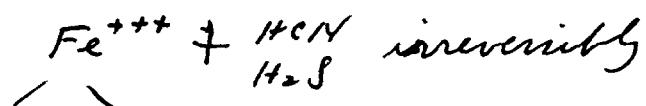
Warburg 1920 - aerobic respiration

- narcotics inhibit respiration
- $H_2S + HCN$ " " very effectively

Fe essential in aerobic oxidations

$H_2S + HCN$ reacted specifically with Fe
to inhibit aerobic oxidation

- CO poisons aerobic respiration



+ CO \rightarrow reversible in presence
of light of certain wave
lengths

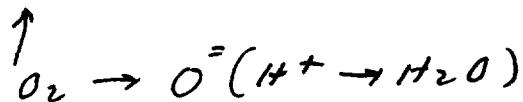
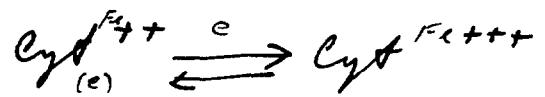
Precursors:-

- 1886 -
- myohematin isolated from blood
- characterizes absorption band
- 1925 - renamed cytochrome - found universally
in animal tissues
- characterizes abs. bands only in reduced
state

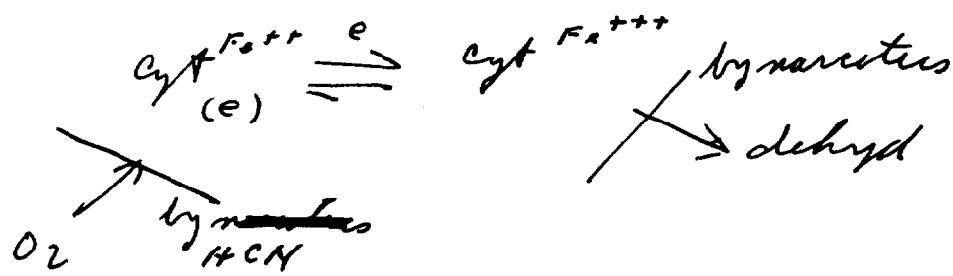
3 cytochromes - A, B + C.

- all have heme nucleus

- Keulen found narcotics inhibit reduc. of
cytochrome
- methanol etc



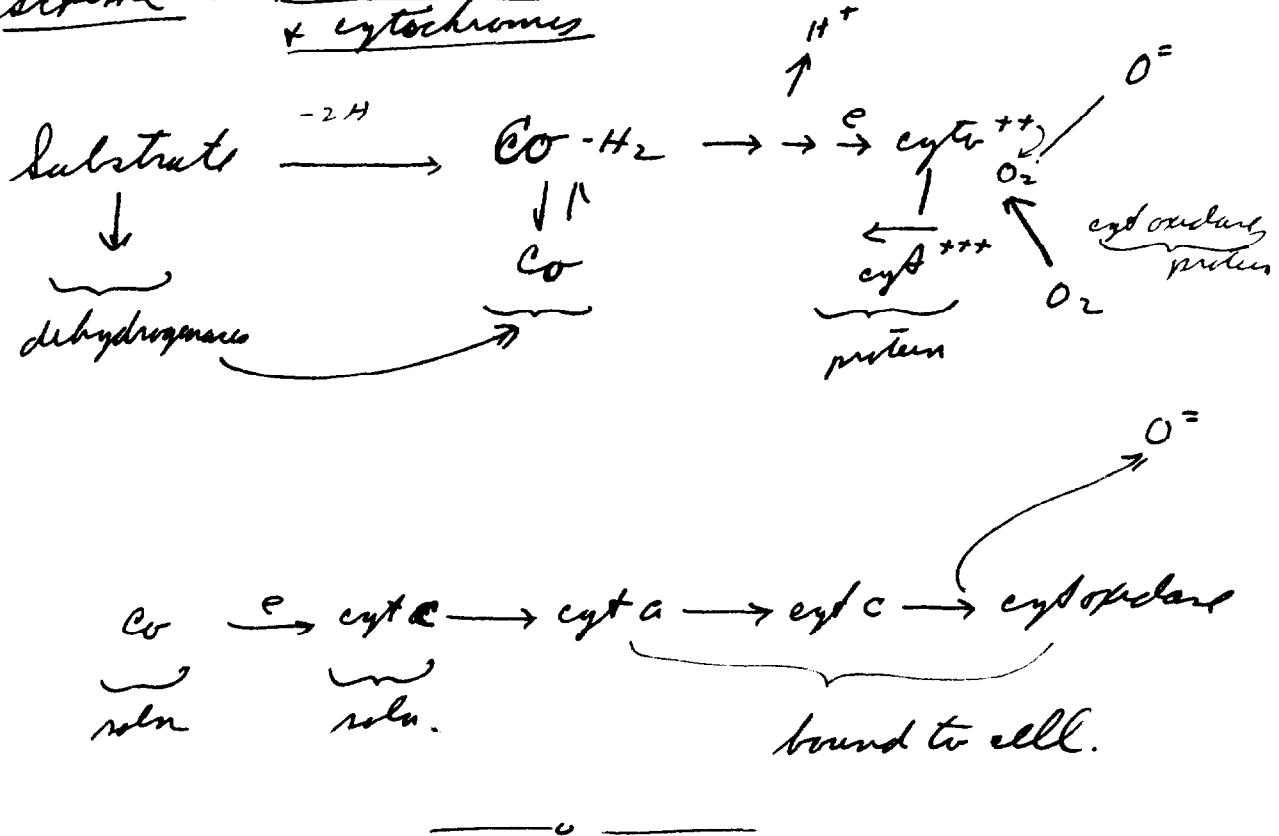
re: -



The enzyme is - endoplasmic oxidase

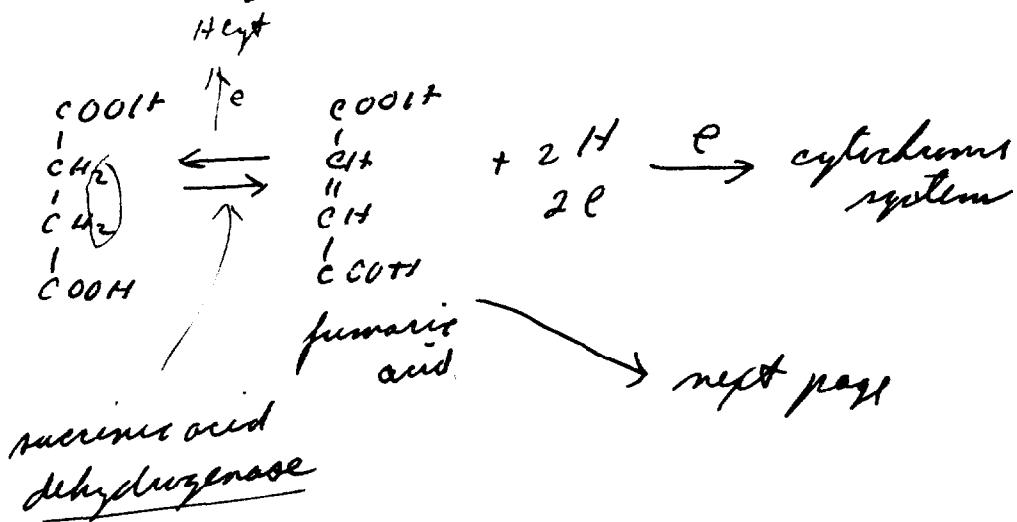
- Warburg resp. enzyme.

Scheme - Relations between dehydrogenase systems & cytochromes

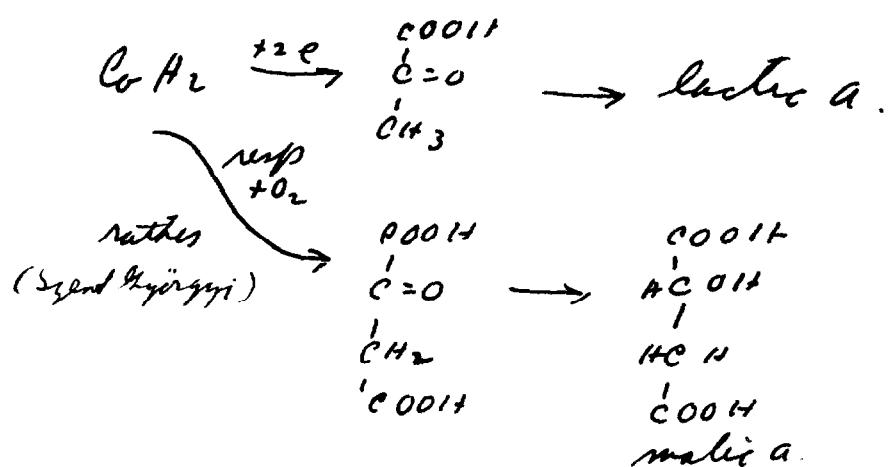
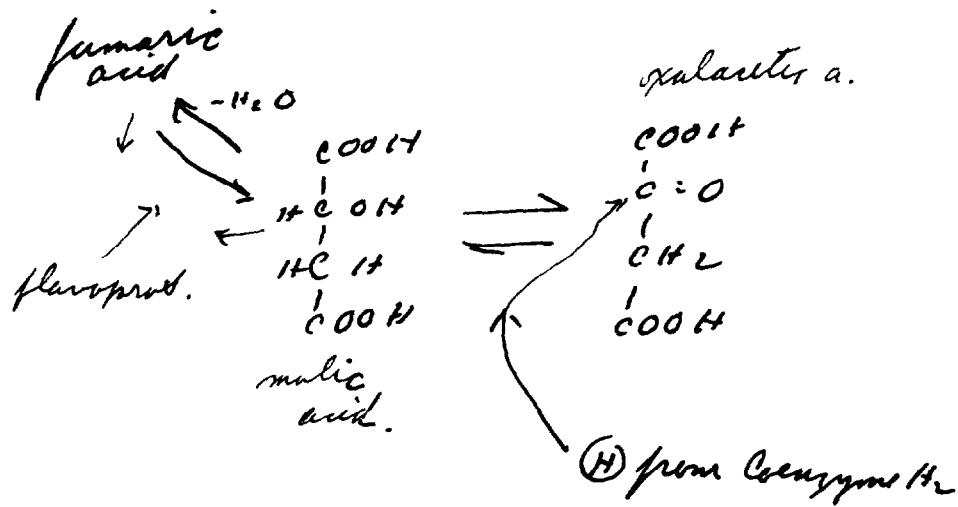


Szent Györgyi -

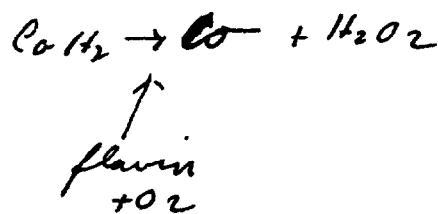
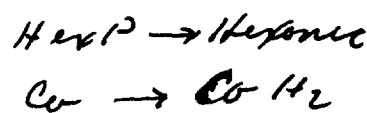
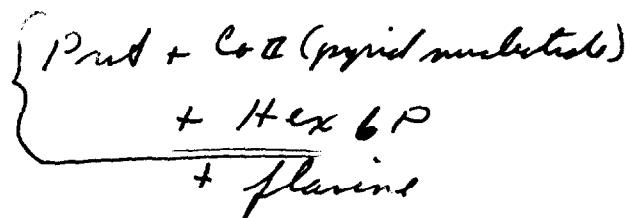
Succinic acid dehydrogenase found to be the only one able to reduce cyt c.



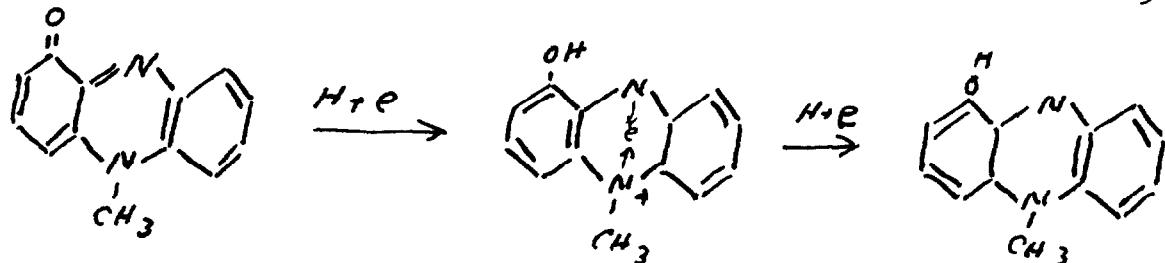
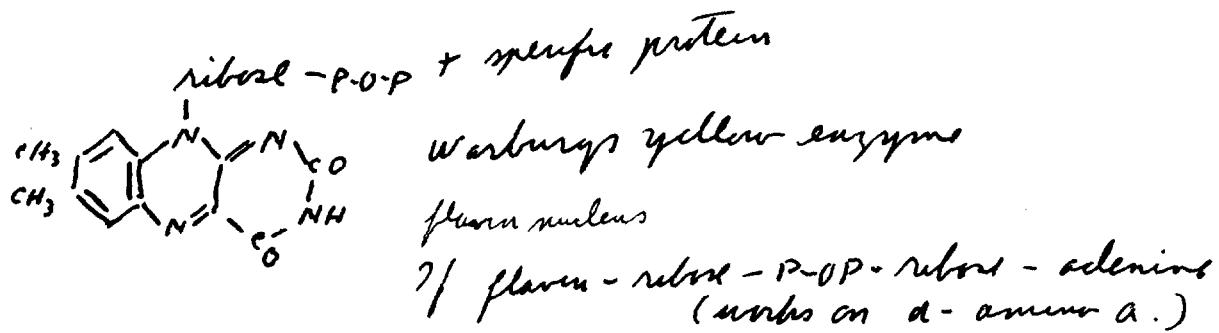
$\begin{matrix} \text{COO}^- \\ | \\ \text{CH}_2 \\ | \\ \text{COO}^+ \end{matrix}$ blocks much because malonate
 $\begin{matrix} \text{COO}^- \\ | \\ \text{CH}_2 \\ | \\ \text{COO}^+ \end{matrix}$ and can't be dehydrogenated



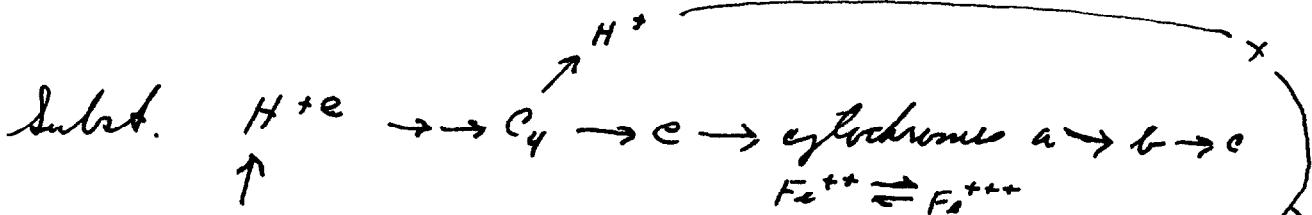
1932 - Warburg - isolated iron free respiratory
 enzyme
 - alloxazine



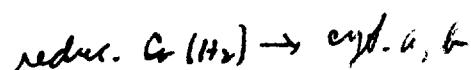
1/30/41) Sg. Györgyi - Oxid, Ferm., etc.



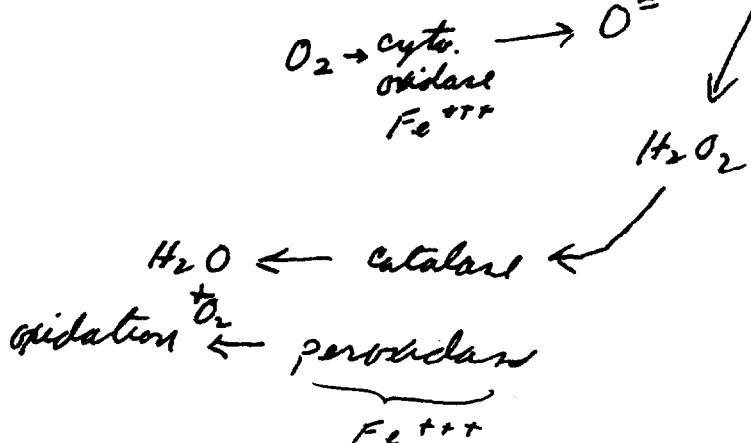
pyoverdins

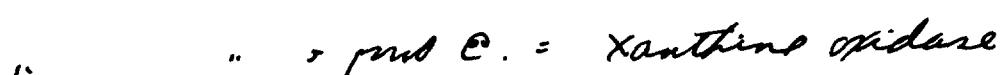
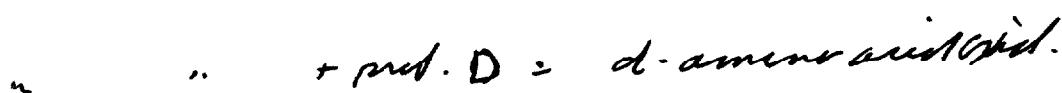
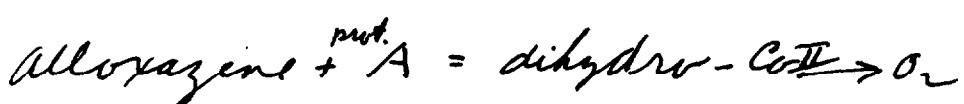
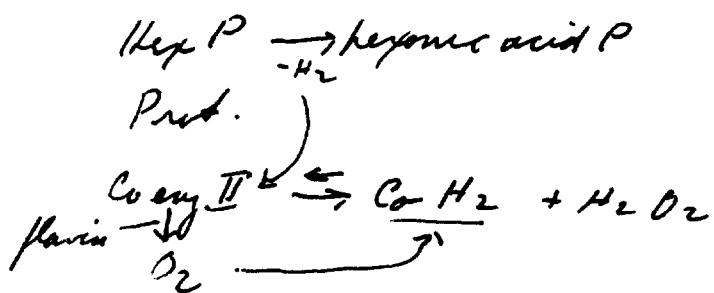
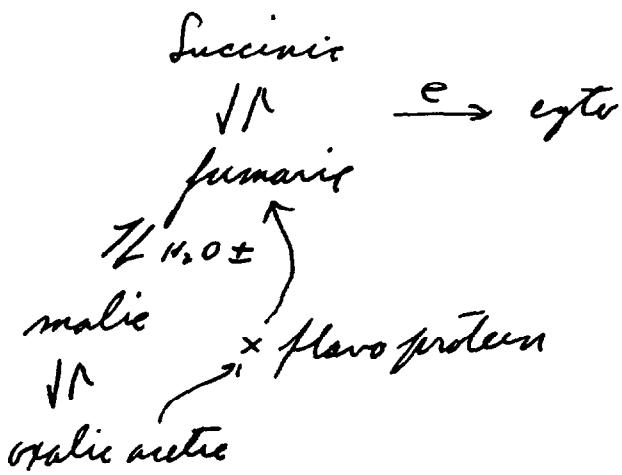


Dehydrogenase:-

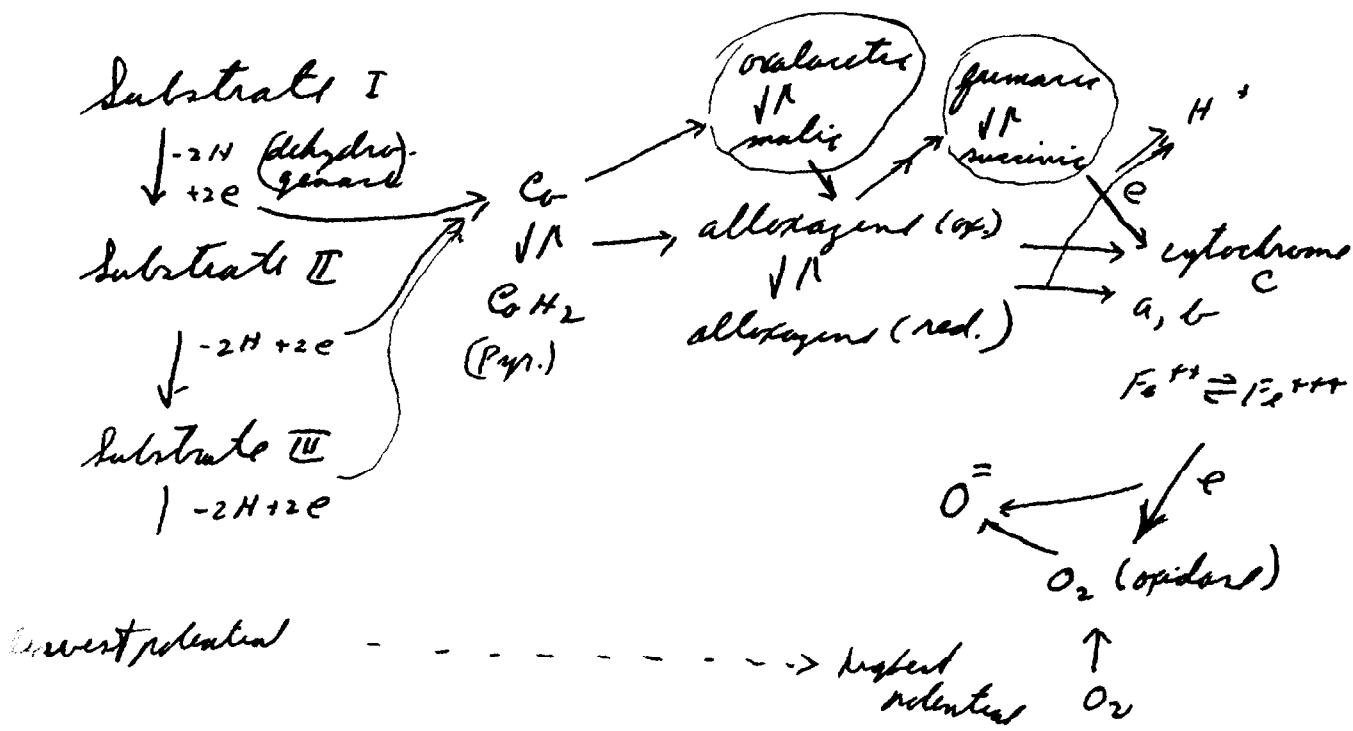


= flavin





Systems involving diff. cycles & reactions :-



Why do above reactions occur?

- oxidation - red. potential.
- measure of tendency of system to give up electrons

Classification into 3 groups :-

(1) Electronotrophic actives ($e^- \rightarrow \text{metal (ox.)}$)

Fe - cyt, cyt oxid -

Flavoproteins

pyoverdine

(2) Sluggish systems (do not react directly with metal)

- slow to equilibrium

- intervention of dyer on Malone electromotrice active system

suchas:-

-SH

ascorbic (vit C)

pyridine nucle.

thiamine -B₁

(3) Sluggish enzymes - react slowly

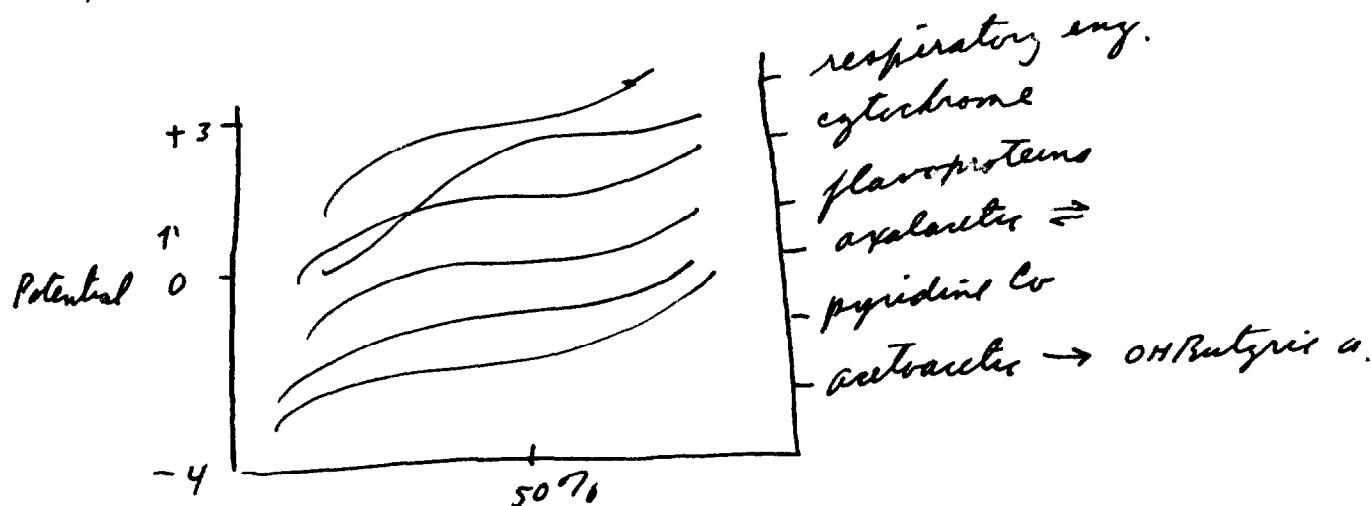
pyruvate \rightleftharpoons lactic

acetoacetate \rightarrow OH butyrate

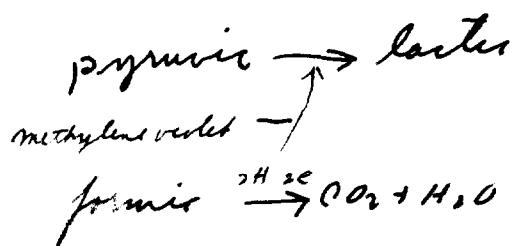
aldehydes \rightleftharpoons EtOH

fumarate \rightleftharpoons succinic

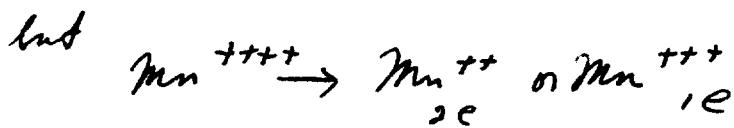
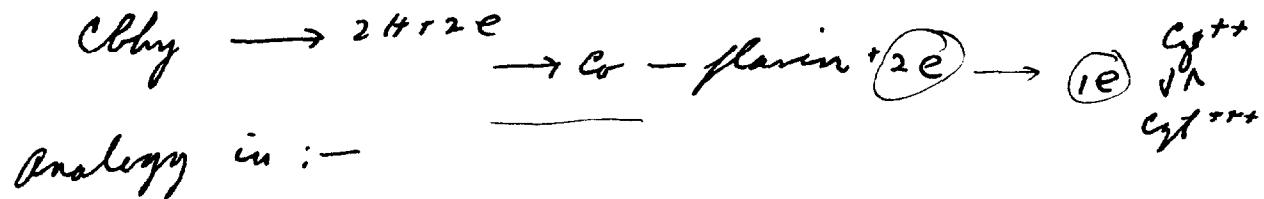
Illustration :-



Eh at pH 7.0



$$\begin{aligned} E_0' &= -0.180 \\ E_0'' &= -0.260 \\ E_0''' &= -0.410 \end{aligned}$$



\therefore Mn act as cat. or intermediate carrier
 in reaction between Co + Tl

2/4/40

Baldwin pp 73-96

Biology Oxidations

Ann Rev. Biophys. '40 p 662

	<u>Hemocyanin</u>	<u>Hemerythrin</u>	<u>Chloromycin</u>	<u>Erythromycin Hb.</u>
color	- blue	red	green	red
metal	- Cu	Fe	Fe	Fe
proto. gp.	- S-pept.	haem?	haem	haem
mol O ₂ /metal	- 1:2	1:3	1:1	1:1
cc O ₂ /100cc	- 2, 8, 3	2	9	1.5-6.5 9-12
occurrence	- crustacea molluscs	annelids	annelids	insect vertebr.

Different Respiratory Mediators in different Organisms

Pyr. Nucleotides coenzymes }
Flavins } H + electron carriers
Flavoproteins
Thiamins

C₄ dicarboxylic acids - H + electron carriers

Substrates →

dehydrogenase

Also depends upon potential of systems

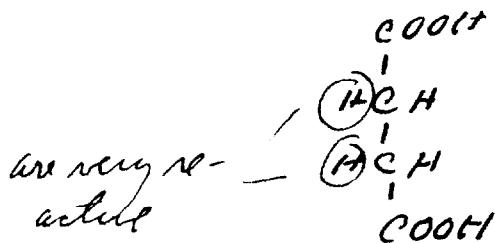
Protein attached to prosthetic group greatly increase potential of systems.

Valence change - gradient change between oxidized & reduced forms

Significance of Structure of Substrates & Mediators

Substrates:-

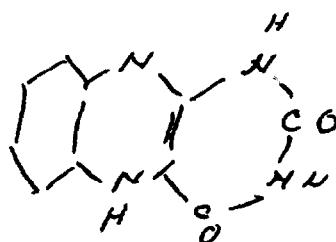
- $C=C^-$ can take up & lose electrons
- $C \equiv O$ readily



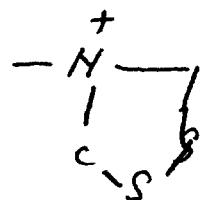
Pyridine nucleotides



Flavins



Thiamus



Cytochromes



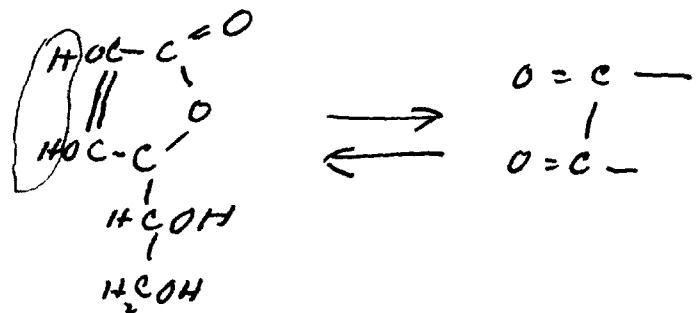
Other mediators



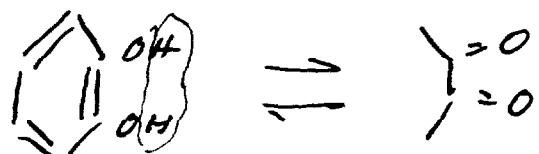
Optional routes in mechanisms of respiration

The optional mechanisms: - In plants
Cu protein.

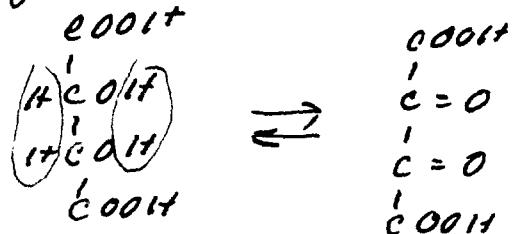
Ascorbic acid - oxidase system (functions in 1/10 plants)
 This may replace cytochrome - cyt oxidase system



Catechol - oxidase system (functions in 1/2 of plants)



Dioxygen malic acid - oxidase system (functions in all plants)



In general - 2 types of respiratory mediators

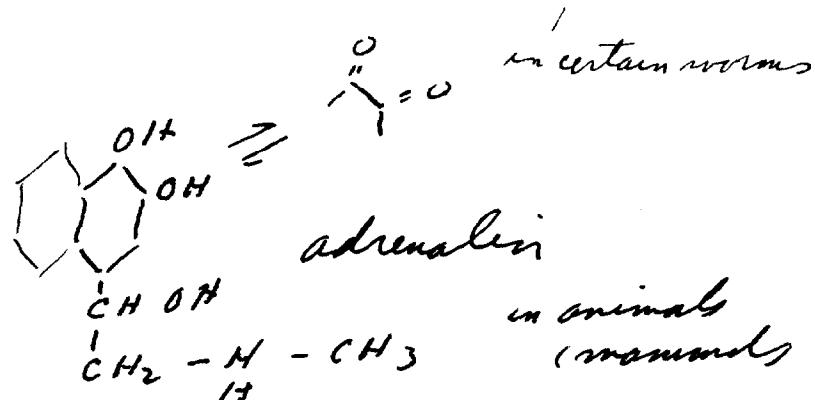
(1) - production of " bonds

(2) - metal containing (Fe^{++} - Fe^{+++} etc.)

Organic comp'd mediators

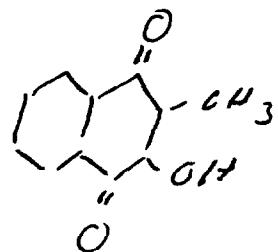
pyrimidines }
 thiamin } in both plants & animals
flavins

- quinone oxidase systems - Catechol +
 (in plants & animals) also  Hallechrome
 $\text{O}=\text{C}_1\text{H}_2\text{O}_1\text{H}_2\text{C}_1=\text{O}$

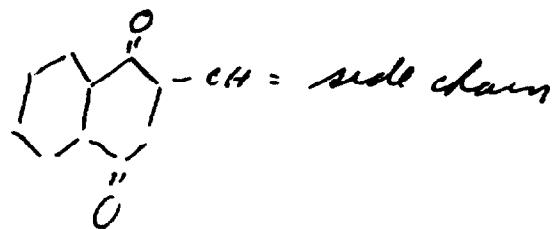


- naphthoquinones

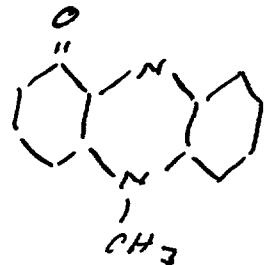
phthalocyanine
 T.B.



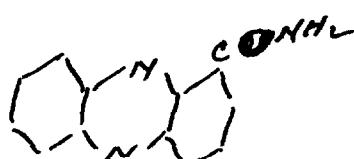
lumatrel



- plenazines



pyocyanines - bacterial pigment
functions oxidations - re-
ductors

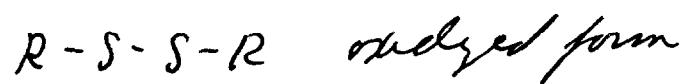
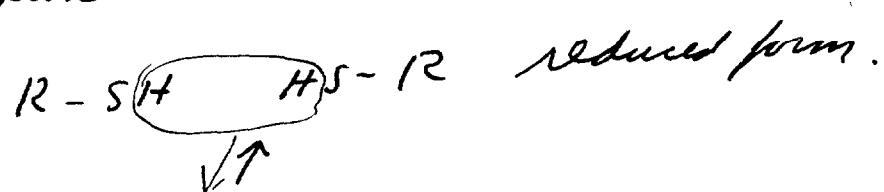


chlororaphine - in bacteria

- ascorbic acid - oxidase

- C₄dicarboxylic acids -

- glutathione



Metal centred complex mediators

Cu + Fe + Al

Mg - phosphorylations etc.

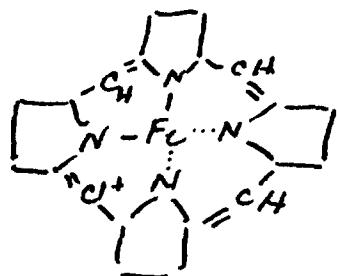
Vanadium

Zn

Mn

These metals act as catalysts & are often found in certain enzymes & enzyme systems

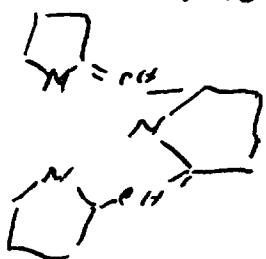
Fe :-



porphyrin + side chains = porphyrin nucleus

porphyrin nucleus + Fe = haem

protoporphyrin - first 3 pyrrole rings - no metal
oxidoreductases in certain insects
bacteria

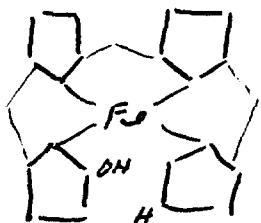


(46)

Bile pigments



Bile pigment haemochromogens



"cytochrome" archaeobacter

chlorophyll

porphyrin nucleus + Mg + phytol side chains

Correlation between various systems : - contg Fe

A Prost. cytochrome - a, b, c.

B cyto - oxidase (O₂)

C catalase

D peroxidase

E(Mg) chlorophyll (Mg)

2/6/41

Biol. Oxid. 254-257

Schmidt: Amino Acids. Ch IV

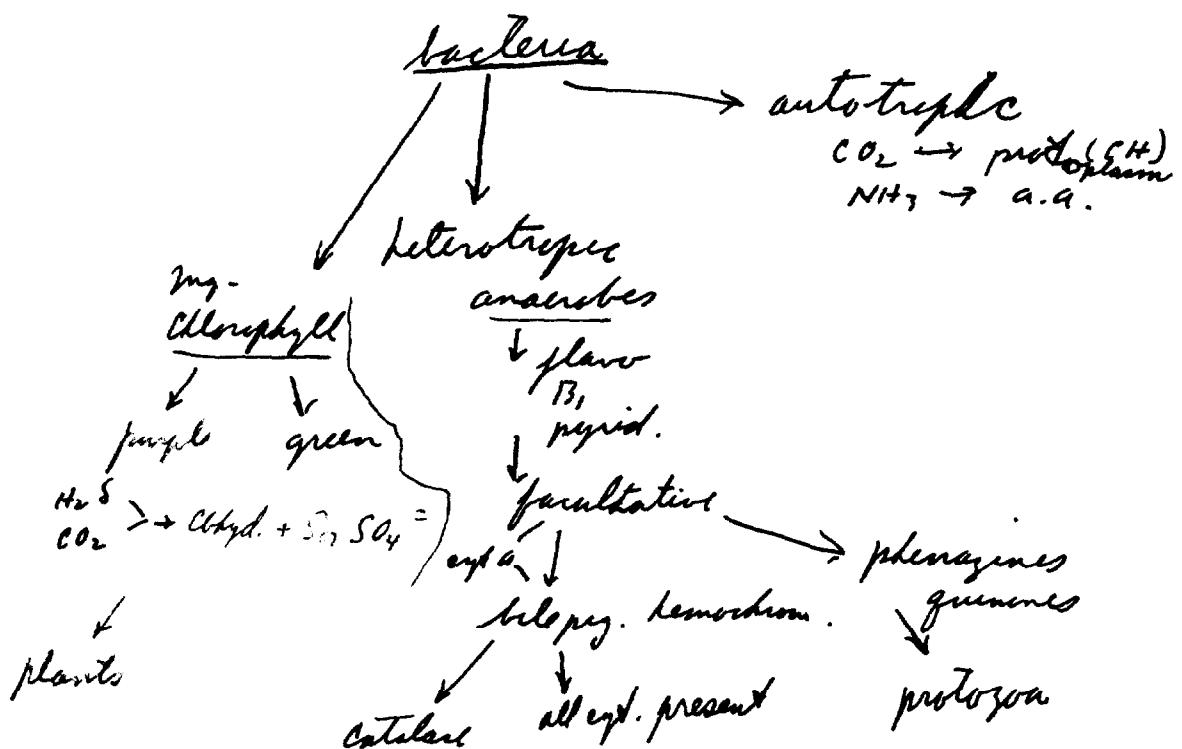
Stephenson Ch. IV

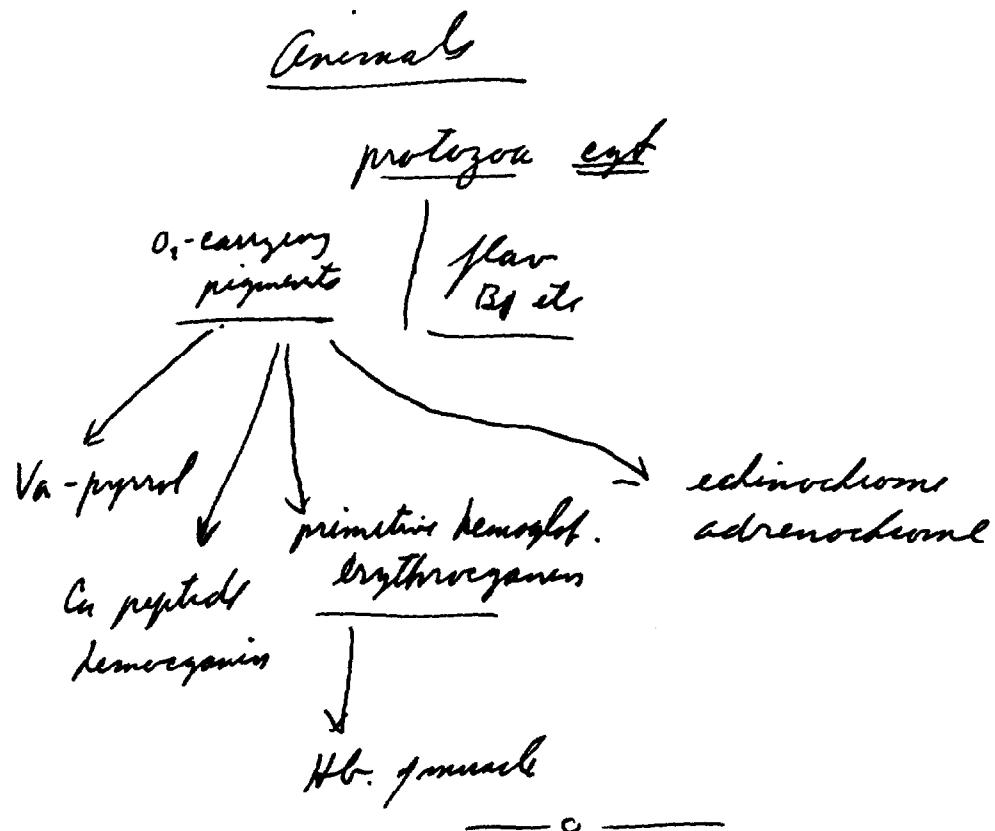
Ann. Rev. Biochem. '36 p 247

" " " '40 p 239

Note on Evolutionary Aspects of Plant Material

- All organisms make use of fundamental oxidative mechanisms including flavins, pyrim. nucleotides, thiamins etc.
- (Except auto trophic bacteria)





Oxidation of Fats + Amino acids

- protein → deamination + oxidation
- Deaminations in liver + kidney (animals)

Energy from a.a.

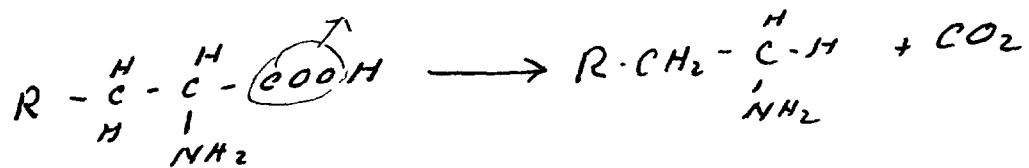
- protein sparing actions of catabol. (in animals)

Fats + fatty acids - dehydrogenation + oxidation

~~decarbox~~

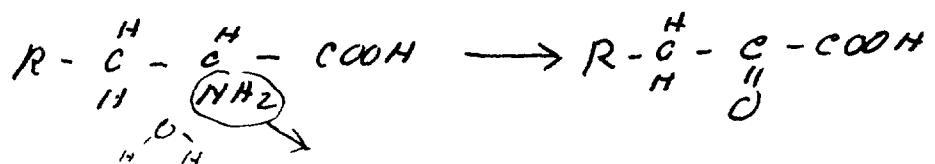
Mechanism of decarboxylation & deamination of amino acids

In bacteria :-



B. coli - enzymes of a.a. decarboxylation

- these enzymes are specific for different amino acids
- each such enzyme has optimum pH.



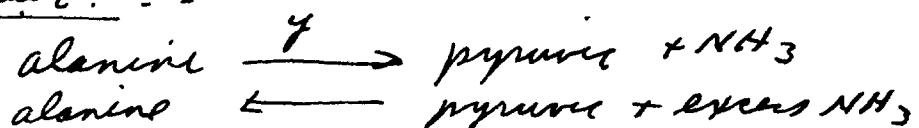
B. coli - enzymes of a.a. deamination

- the deaminase linked with FAD.
- also protein specificity of deaminase

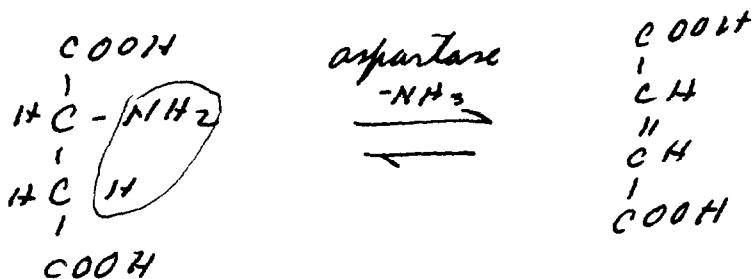
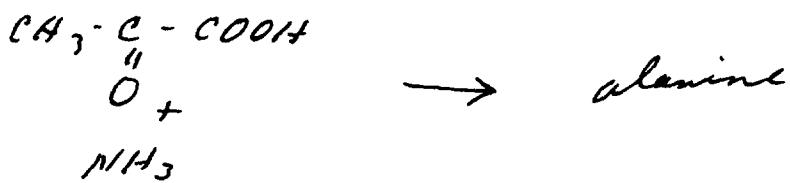
B. coli - in acid reactions, the decarboxylase is active & deaminase inactive.
Vice versa in alkaline reaction.

Neutrophil :-

Neutrophil :-

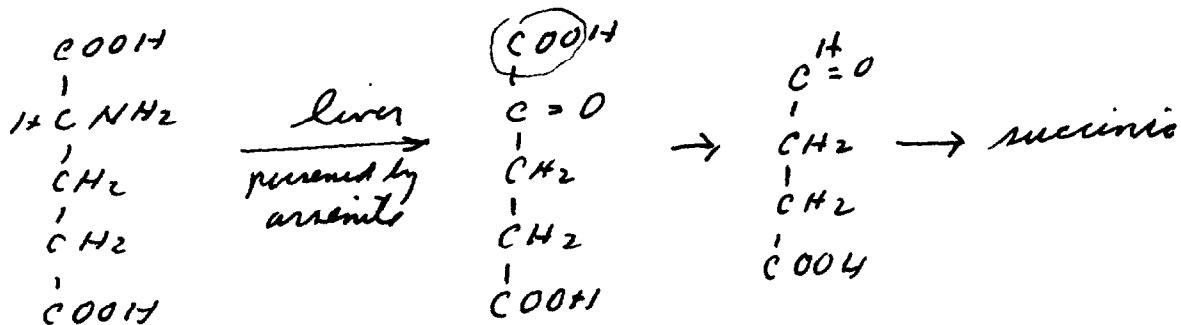


(28.)

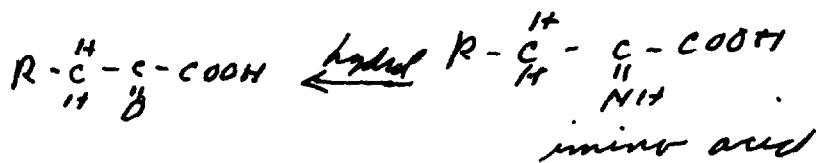
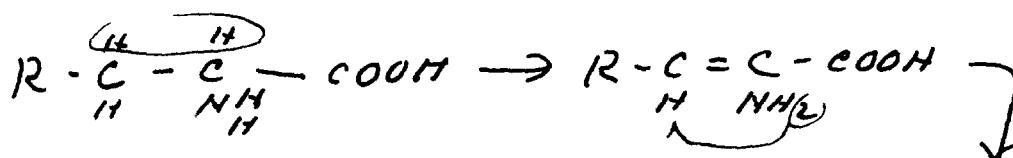


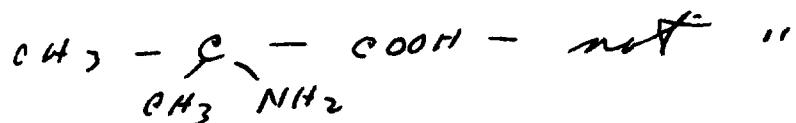
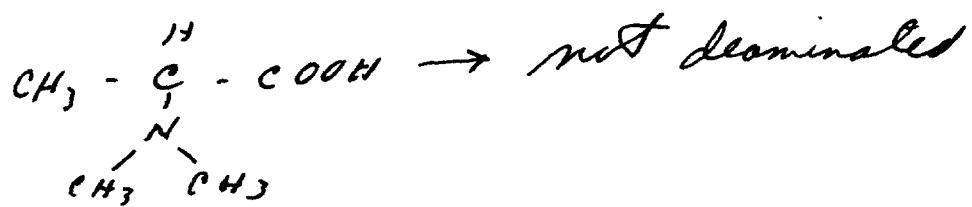
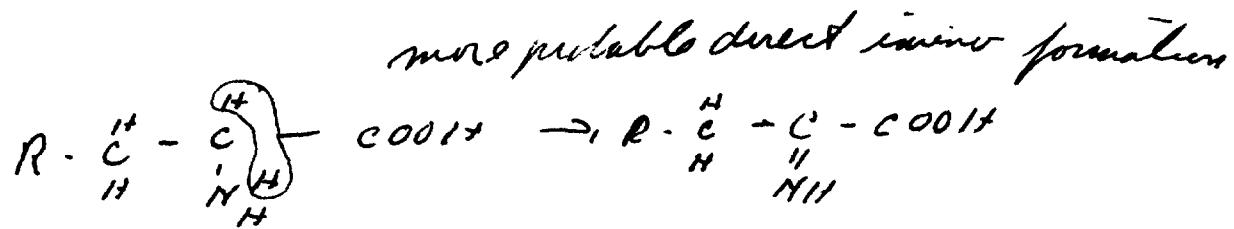
Aspartase of *B. coli* requires a coenzyme, namely a_{TP} :—
adenine phosphate flavoprotein.

In animal : - deamination

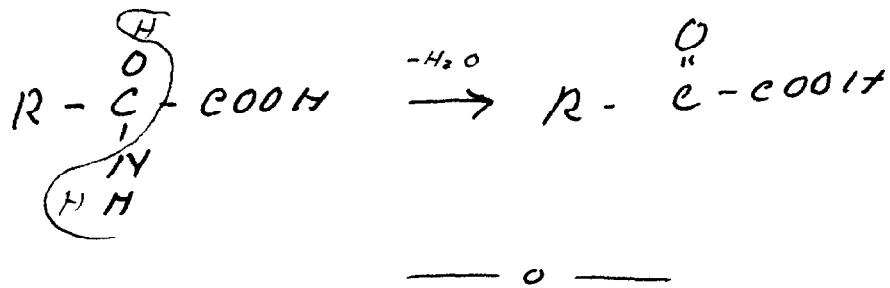


Deamination in liver without decarboxylation

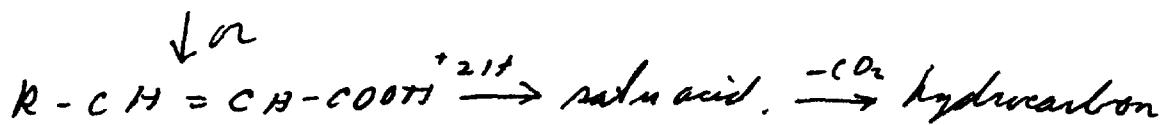
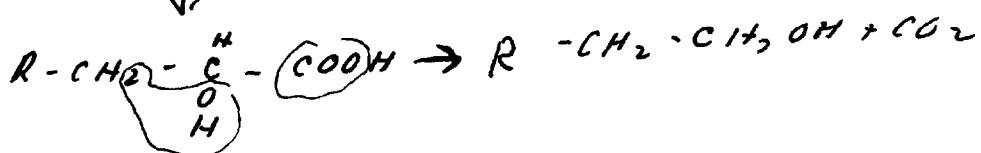
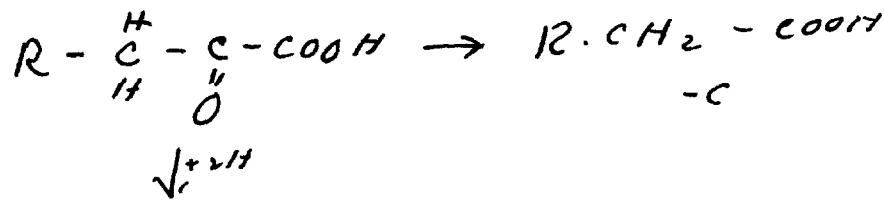




\therefore a H must be on α C & on N atoms for deamination



Decarboxylation of α -keto acids from a.a. deamination



(29)

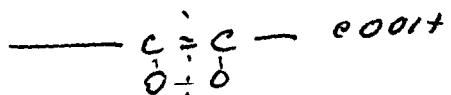
Many of the enzymes involved in a.a. oxidative mechanisms are the same or similar to those in oxidative mechanisms of abhyd.

Oxidation of Fats :-

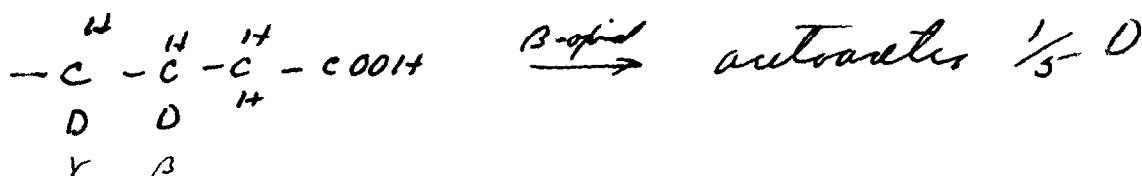
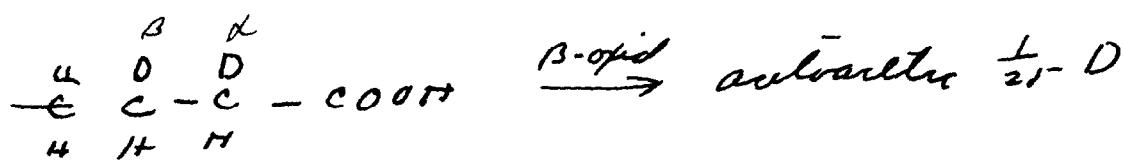
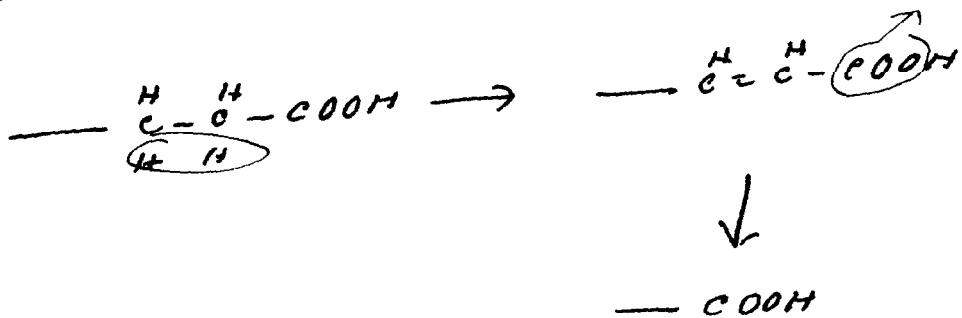
- involves typical dehydrogenases.



or



β -oxidation is typical oxidation of fats :-



2/11/41)

Clifton & Logan (1939)

J. Bact. 37, 523

Wenzel & Bannister ('38)

J. Cell. Comp. physiol.

Ann. Rev. Biochem. '38 - 40 Carbohydr. Met.

Fat & Carbohydrate Synthesis in Animal Organisms

Utilization of Energy from oxidation :-

- Synthesis
- Growth etc.

Deficiency of aerobic versus anaerobic oxidation :-

- greater amt of energy available under aerobic oxidation
- cited example of bacteria + yeast + molds production of or rather synthesis of carbohydrates + fats under aerobic + anaerobic conditions
- amt + kind of substrates present also have control on rate of synthesis of fat + carbohydrates.

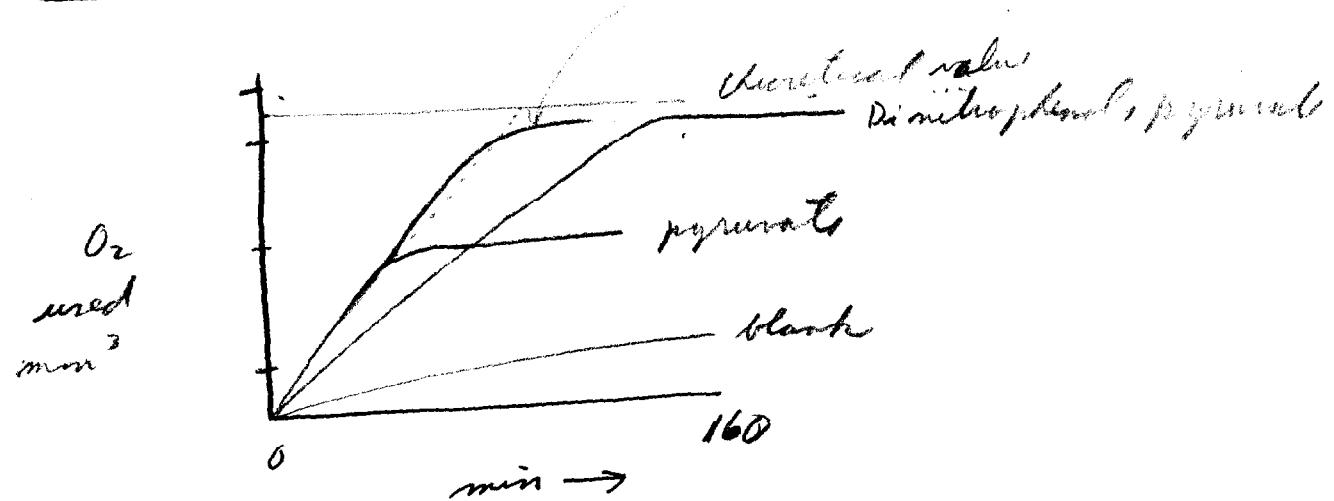
30.

Rates of respiration & synthesis compared :-

- Respiration is incomplete since less than theoretical amt of O_2 per unit wt. substrate is used.
- Respiratory quotient is near 1 in case of organisms metabolizing aldehyds.

B. Coli :-

pyruvate + $NaNO_3$



In the case of the poisons $NaNO_3$ + DNP, the oxidation of pyruvate is almost complete because poisons inhibit synthetic processes.

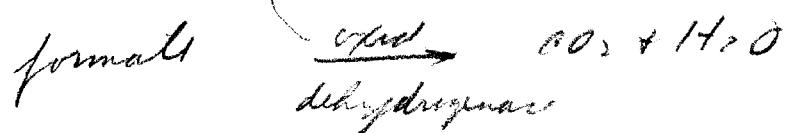
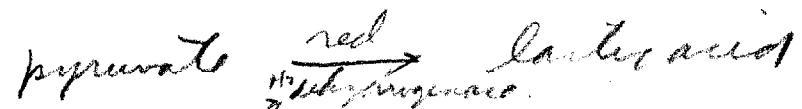


$\frac{1}{3}$ substrate is synthesized to aldehyd.

glucose is almost 50% assimilated

Synthetic processes may be poisoned selectively.

The ratio of amt oxidized & synthesized is constant in spite of changes in conc. of substrate.



Toluene does not affect dehydrogenase but affects coupling link between oxidation & synthesis, \therefore inhibits synthesis.

Efficiency of aerobic versus anaerobic synthesis: -

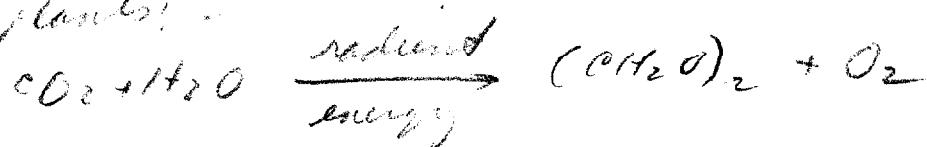
	ΔF_{synth}	$\frac{-\Delta F}{\text{molecules}}$	% accumulated	% loss	Efficiency %
glucose oxid.	7,320	700,000	73%	26%	2.88
" form.	7,320	66,000	24%	70%	4.62
adult oxid.	39,850	230,000	41%	58%	12.2

as these two values approach each other the synthetic mechanism approaches 100% efficiency.

Animals :-

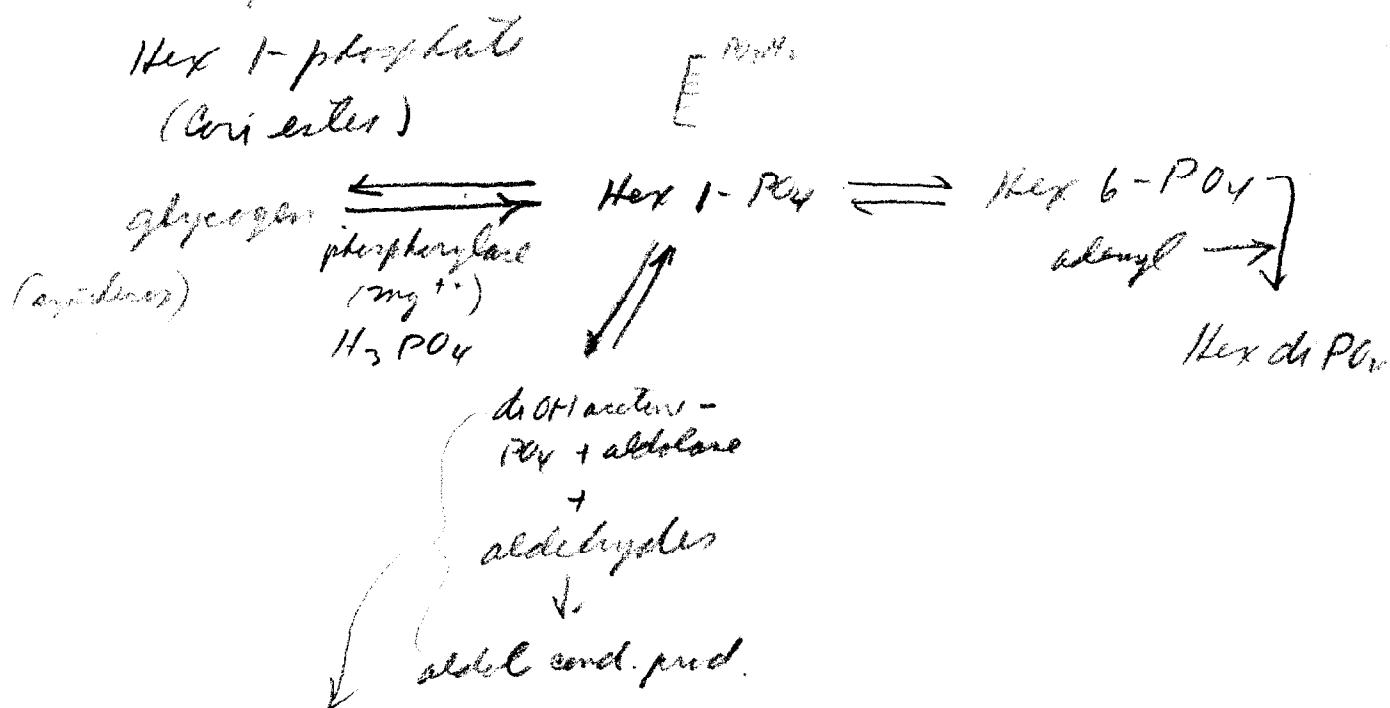


Green plants:-

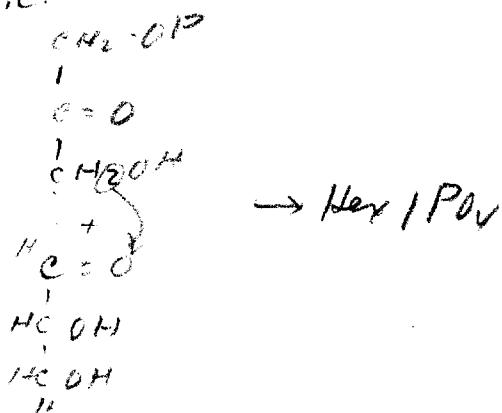


— o —

Mechanism of Glyc. d. Synthesis in Animals :-

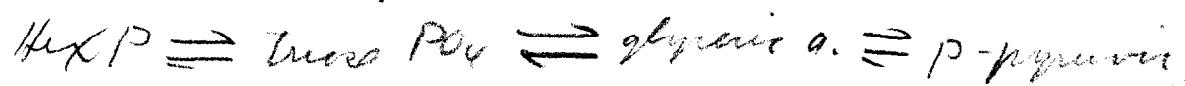


i.e.



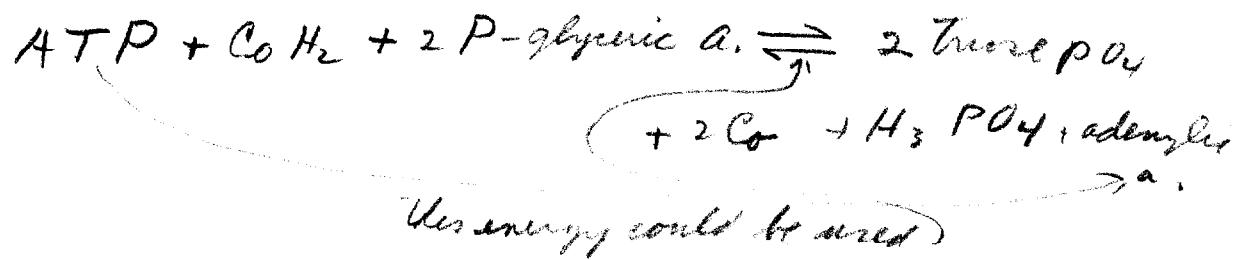
hex synthesis
mechanisms are
poisoned.

all are reversible as follows - (enzymatically)

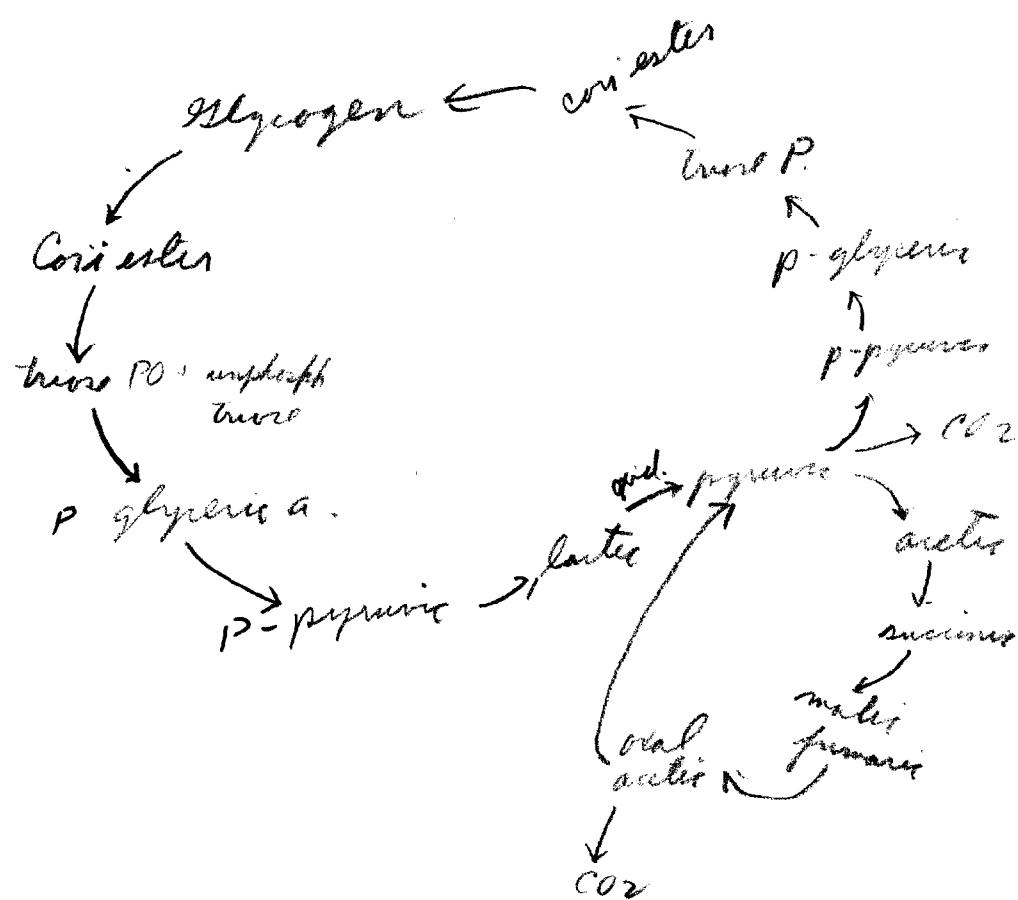


$\xleftarrow{\text{Pyruvate kinase}}$ $\xrightarrow{\text{coupled}} \text{ATP}$ $\xleftarrow{\text{energy}}$
 (not re-)

Linking of energy with synthesis -



In animals, synthesis is related with the dissimilation :-



$$\text{Glycerol} \xrightarrow[\text{yeast}]{\text{liver}} \text{Glycogen}$$

" $\xrightarrow{\text{nitrate}} \text{phosphoglycine}$ starch

Specificity of phosphoenol protein decides whether starch, glycogen etc shall be synthesized.

Synthesis is the reversal of dissimilation, an example of carbohydrate synthesis.

Baldwin - Ch IV + V

Annu. Rev. Bioch. '60 p 282-284

Interrelations - a. acids:-

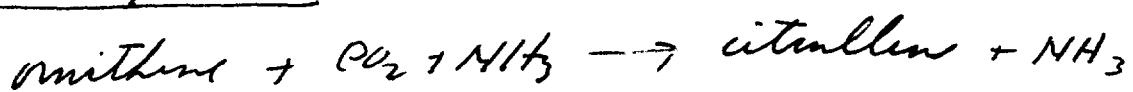
Krebs - Enzymology I, 5-3 ('39)

What happens to N of a. acids & purines when metabolized in animals:-

- simplest form of excretion is NH_3
(bacteria etc.)
- trimethylamine oxide in some aquatic forms (non toxic form)
This is marine aquatic forms.
- amphibian forms detoxify NH_3 by production of urea
- terrestrial types excrete urea
- birds & reptiles excrete a.a. N as uric acid.

- Supply of urea detrs whether urea or uric acid is excreted

Production of urea :- see text.

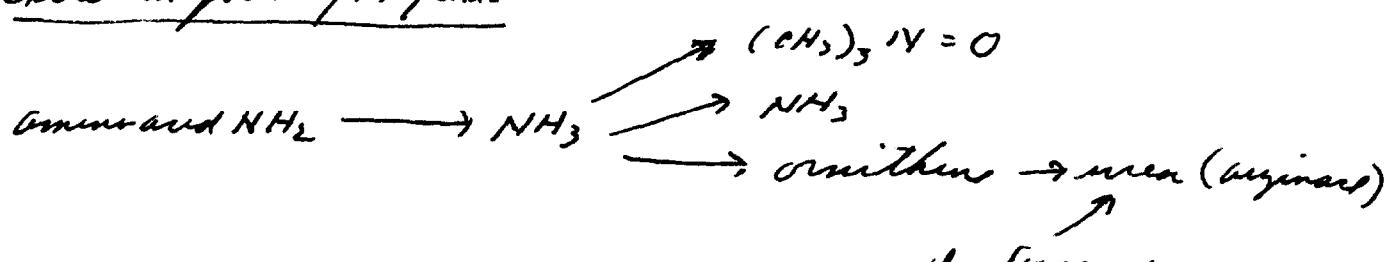


This scheme involves enzymes.

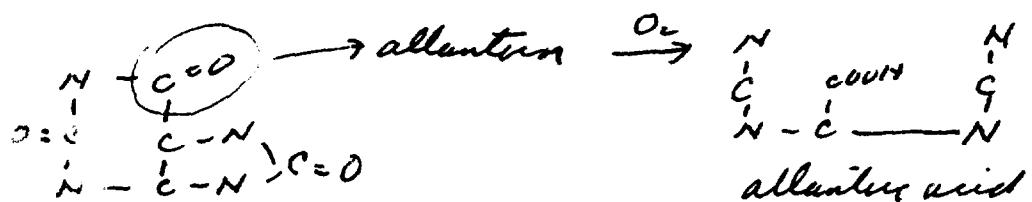
In mammals - break down of purines -

purines split to give allantoin (synergistic action)

Excretion forms of N of a.a.



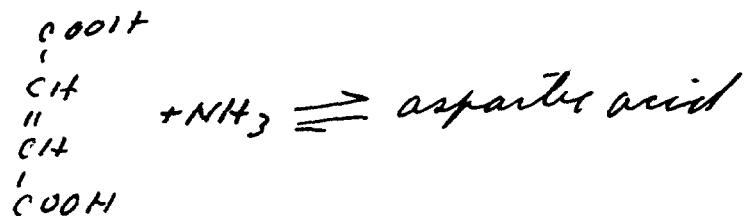
Excretion forms of N of purines



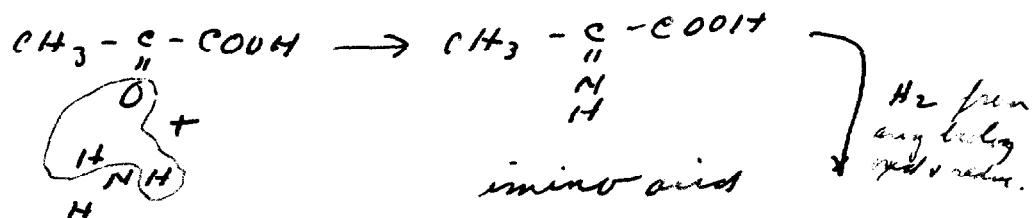
33.

Synthesis from a. acids :- Three type

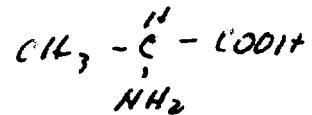
(1) Aspartate



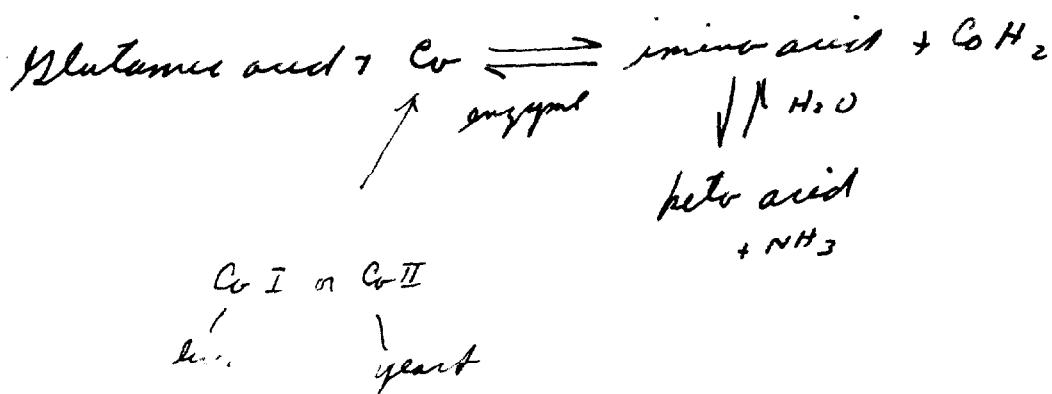
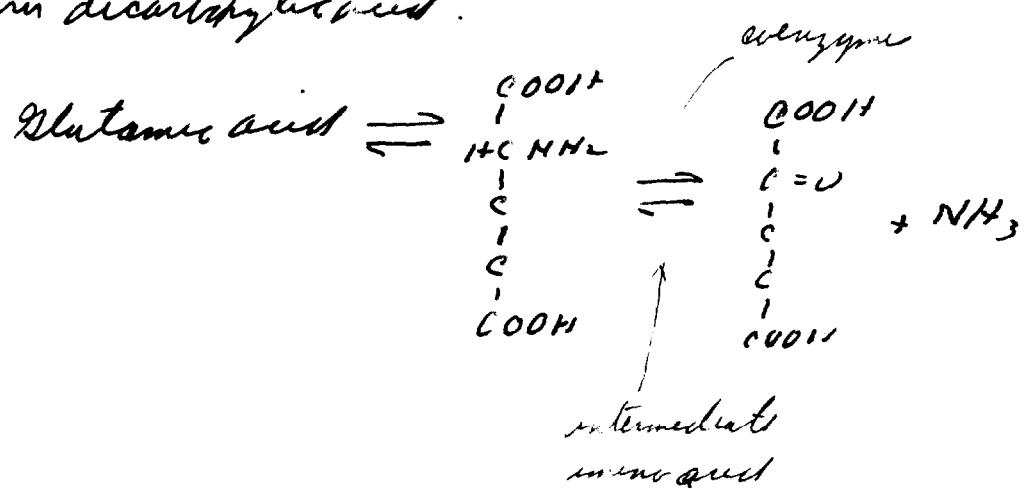
(2) addition of NH_3 to α keto acid (pyruvate)

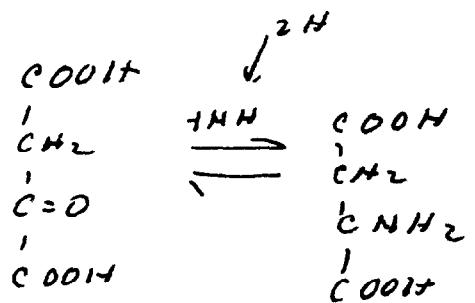


This reaction may
not take place directly

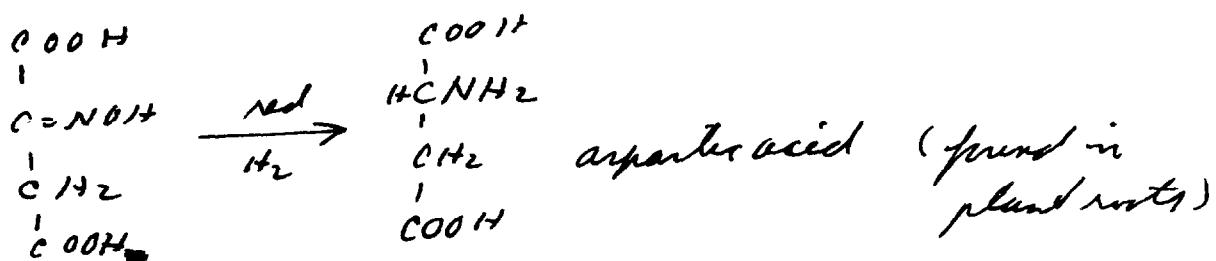


(3) Through decarboxylase.



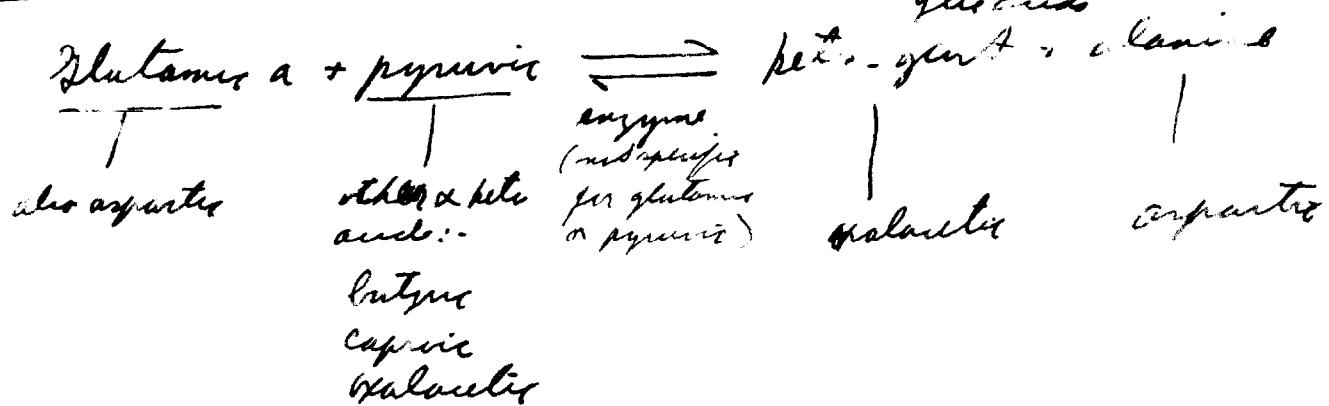


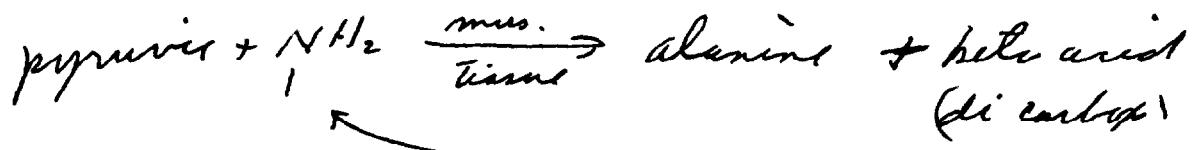
in leguminous
plants $\downarrow \text{NH}_2\text{OH}$



Keto glutaric acid & oxaloacetic acids only dicarboxylic acids which can be directly enzymatically converted to a. acids

(4) Another method of a. a. synthesis :- transfer of $\text{NHC}_6\text{H}_4\text{NH}_2$ groups to α, β -dicarboxylic acids





However, this amino group may be obtained not only from Ds - COOH acids but also from acids such as :-

SO_3H	SO_3H	PO_3H_2	COOCH_2	COOCH_2
CH_2	CH_2	O	CH_2	CH_2
CH_2	CH_2	CH_2	CH_2	CH_2
CH_2NH_2	CH_2NH_2	CH_2NH_2	CH_2NH_2	CH_2NH_2
COOH	COOH	COOH	COOCH_2	COOCH_2
systems			serine P.A.	

All acids with groups as indicated below line will give up - NH₂ group to α keto acids such as pyruvic acid.

— O —
this will not occur except thru
some dicarboxylic acid.

Lysine $\xrightarrow{\quad}$ pyruvic $\alpha \longrightarrow$ alanine
 \downarrow
 & keto

Lysine $\xrightarrow{\quad}$ glutamic \downarrow
 \downarrow
 & keto

pyruvic acid \rightarrow alanine

Synthesis of a.a. & relation to evolution :- Leibniz

	<u>N used</u>	<u>C - source of energy</u>	
blue-gt. algae	N_2 (atm)	CO_2	<u>light</u> (H_2O)
photosynthetic autotrophic bacteria	NH_3	CO_2	<u>light</u> (H_2S)
chemo-synthetics	NH_3 NO_3^-	CO_2	$H_2S \rightarrow S$
facultative heterotrophic bacteria	NH_3	CO_2 (CH_2O)	inorg. oxid. oxid of (CH_2O)
obligate het- erotrophic bacteria	NH_3	(CH_2O)	oxid of (CH_2O)
> N-fixation bacteria	N NH_3	"	"
Plants	NH_3 or NO_3^-	CO_2	<u>light</u>
Rhizobium	N_2	(CH_2O)	oxid of (CH_2O)

Dissensibility & Indispensability of a. acids

(35.)

Essential a. acids :- see text.

The, two others branched chain,
complex w/ a. indispensable
such as L-tyrosine

2/18/41)

Lwoff - Ann. Inst. Pasteur
61, 580 (1938)

Knight - Recd. Nutrition (1936)
Monograph - pp. 137-161

Williams - Biol. Rev. 16, 49 ('41)

Growth factors in bacterial metabolism:-

- Complex nitrogenous substances are very often growth factors rather than an indispensable source of N for bacterial growth.

Correlation between growth factors, ability to synthesize + position of organisms in evolutionary scale.

- Go up along evolutionary scale, ability of

organism to synthesize growth factors (Vitamins in high evolutionary scale) seems to fall off. These factors must be obtained from outside source.

Growth factors are important & indispensable.

- They sometimes form prosthetic groups of respiratory enzymes.
- Factors must be present in almost all forms of life

Growth factors which are constituents of respiratory enzymes

Haematin (Fe containing porphyrin)

Nicotinic acid ~~&~~

Thiamin

As regards bacterial growth

- It is sometimes found that certain strains of bacteria are incapable of synthesizing a few growth factors necessary for normal growth. These factors must be supplied.

Example: -

Hemophilic bacteria: -

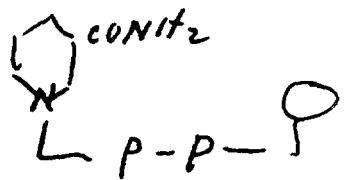
- must obtain haematin for aerobic growth
- also a pyridine nucleotide.

Sarcina aureus

- requires Vit B₁ (from outside source) for normal growth.
- niacinic acid etc.

Development of organisms as regards their synthetic ability

Coenzymes: -



Some organism just requires niacinic acid & can synthesize from ~~then~~ then on. Other organisms must be supplied with the whole molecule.

Similarly with Vit. B₁

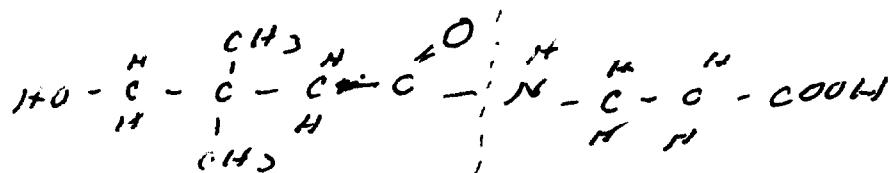
Vit B₁ = pyrimidines + thiazole

Some organisms require only one or the other of above constituents for complete synthesis of B₁. Other organism can't synthesize B₁ at all from one or both of above constituents & but must be supplied with B₁.

2. Vitamins required by many forms of life (must be supplied)

Vitamin B₁ - required by many animals & micro-organisms. Ability to synthesize is lost by these forms of life.

Pantathene acid :- an essential factor for yeasts



certain hemophilic
bacteria can form
pant. a. from above
portions of its molecule.

certain yeasts can
synthesize pant. a. from
alanine portions alone

Biotin :- required by certain fungi (in their
respiratory cycles)

Vit H :- forms dermatitis in rats if not present
when rat diet is high in egg-white.

Vit. B₆ - bacteria, insects & animals require
it
- has some function in plants.

Inositol (cyclohexanol) :- factor in mice.
- prevents falling hair (in mice)

(32)

Cholesterol :- required by protists etc
- This might be a phytochemical precursor
of Vit D.

Many water soluble B factors :-

Some of the above may be stimulatory growth factors :- that is they stimulate its synthesis which is normally slow in the organisms

Only portions are necessary for complete synthesis of the growth factors in certain other organisms

In high forms of life practically none of these growth factors are synthesized. All must be supplied.

Where these growth factors are synthesized, it is accomplished by specific catalytic proteins, namely enzymes.

2/20/41

Stephenson ch XI

Knight - Monograph 162 - 175 -

Prospect. Biochem p 91 - 98

Review of Growth Factors & Vitamins

- evolutionary development.
 - loss of ability to synthesize (progressive loss)
 - essential factors - sometimes taken care of by symbiotic relationship

as regards plants:-

- certain portions of plant may have lost synthetic ability. But plant as a whole can synthesize all necessary growth factors.

- Generality of essential growth factors (necessary for all forms of life)
- Loss of synthetic ability is attributed to what?
 - due to loss of ability to produce enzyme which is necessary for synthesis.
 - loss or gain of ability to synthesize based upon environmental changes.

Comparisons of Enzymes in Forms of life along evolutionary scale - Modifications of enzymes due to environment.

- by varying conditions of a specific organism, certain enzymes, can be modified to adapt themselves to environment.

Specific example: - *B. coli*. - does not ferment lactose.

If, however, grown on lactose containing medium, it will ferment lactose after it has completely used up other available sugars. These secondary growths of *B. coli* can hydrolyze lactose for many generations.

This is a sort of mutation & natural selection.

- changing chemical environment of organism & modifications of certain of its enzymes occur.

Karrstrom 1930 - *B. acidigenes*

Fermentation of xylose

Grow xylose - organisms on lactose medium, suspension of these organisms

would be xylose negative if suspended and
in xylose medium containing no N. If
a N source is added, fermentation of
xylose would occur.

Pand et al. found that organism did lack enzymes but was able to synthesize it upon having an acid available in source.

Enzymes which can be lost or gained, upon ^{dependency} environmental change: - adaptive enzymes as compared with constitutive enzymes.

<u><i>A. aerogenes</i></u>		Sorbitol form by suspension		
glucose	xyllose	arabinose	glucose	
glucose	-	+	+	
arabinose		-		
xyllose	+	-	+	

Production of adaptive enzymes is in response to stimulus in form of substrate upon which it is grown.

Hydrogenylase - in *B. coli* - an adaptive enzyme forms $\xrightarrow{\text{CO}_2}$
 $\xrightarrow{\text{H}_2}$

However, does not thrive any better on formate containing medium than on a normal medium.

Inhibition of adaptive enzymes

Production of an adaptive enzyme for a specific polysaccharide - Du Bois - not natural selection since organisms used were suspended in thick, syrupy poly sacch. soln + no growth occurred but adaptive enzyme for hydrolysis of this polysaccharide was produced.

Judkin : - mechanism of production of adaptive enzymes

met. precursors \rightleftharpoons active enzymes

If appropriate substrate is present,
reaction ^{at equilibrium} goes to right. By the
substrate hydrolyzed or its end products
of hydrolysis

Virtanen : - two types of enzymes could be
classified by whether they played
an essential role in metabolism
or whether they prepared substrates
for metabolism by organism

<u>adaptive</u>	<u>constitutive</u>
preparatory	essential
hydr. starch	traces
" factor	glucoses etc
" protease	
etc	

Further classification of enzymes

- (1) - enzymes for specific subst + reaction
- (2) - " for general type of reactions
- certain a.a. deaminases.

- Activity of all enzymes resulting directly from specific structure of enzyme protein component.

2/25/41

Review :-

Bacterial enzymes:-

1. Constitutive
2. Adaptive

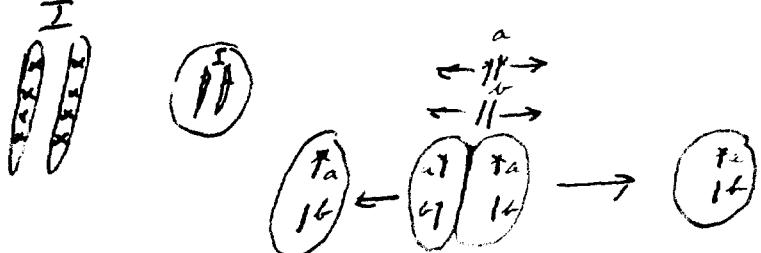
Bacterial mutation:-

B. Coli :- permeability of cytoplasm (enzymes mutation form)
 - mutation is relatively constant & is transferred thru several generations of B. Coli.

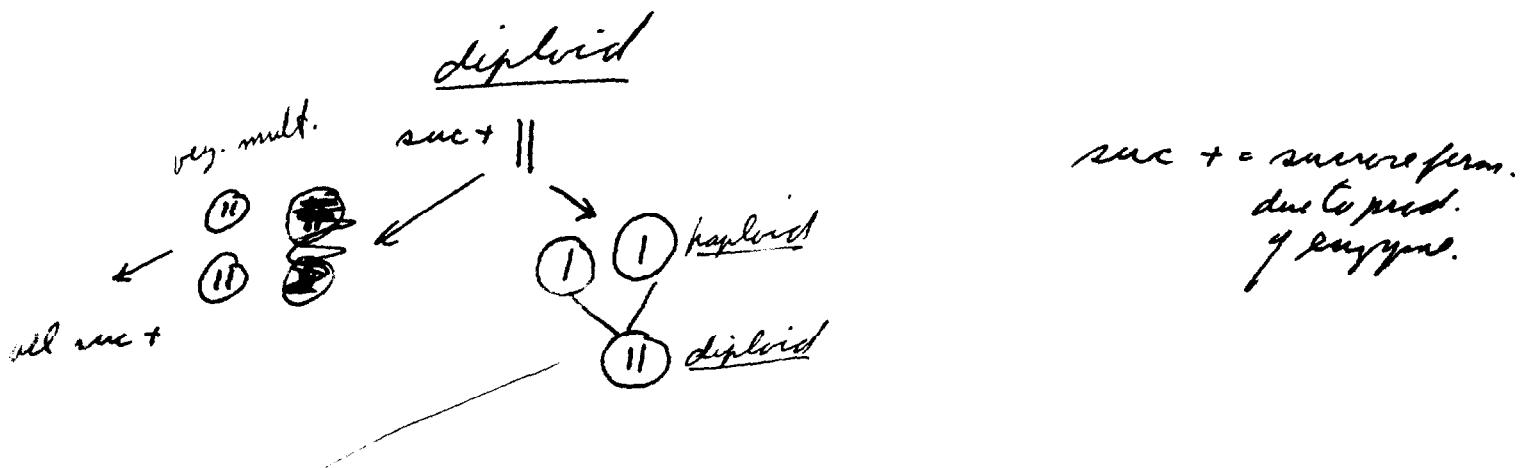
Chromosomes :- subdivided into genes.

Each gene giving organism a specific characteristic

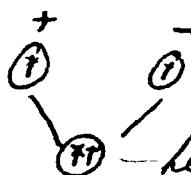
chromosomes occur in pairs in a cell:-



- cell which has 2 of ^{each} same chromosomes = diploid
- " " " only one " = haploid



some yeasts ferment sucrose
" can't "



heterozygous - the heterozygous yeast cell will be able to prod enzyme which ferments sucrose

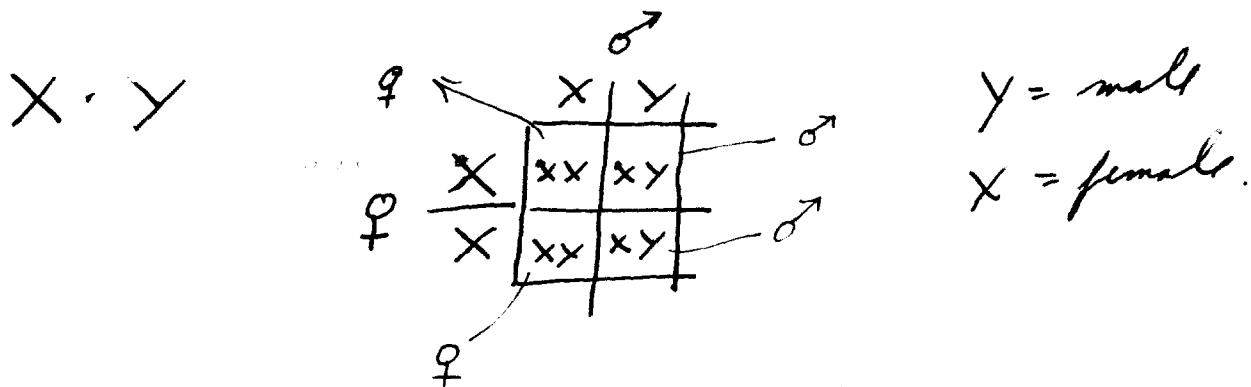
Homologous chromosomes

C + + homozygous (for suc+)

C - - " (for suc-

The prod of enzyme property is dominant in the heterozygous cell.

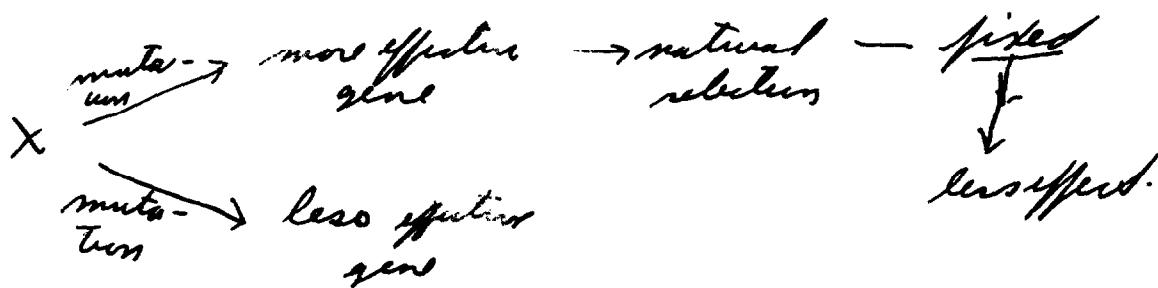
Haploid type



	X^w	Y	
X^+	$^{nig} \quad ^{nig.}$ $X^+ \quad X^w \quad X^+ Y$		
X^w	$^{nug.} \quad ^{nug.}$ $X^w \quad X^w \quad X^w Y$		

$+$ = pigment eyes
 w = white eyes
 $+$ is predominant
 w = recessive

Genes affecting metabolic processes :-



The more effective gene is dominant to less effective gene.

In the case of abld. metabolism in man:-

recessive sugar (diabetes)

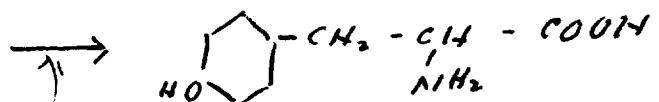
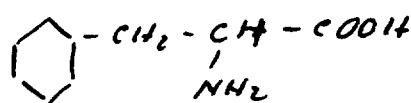
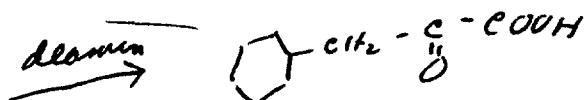
(over) \ominus two genes forming one all inable of metab. sugar.

recessive

pentosuria

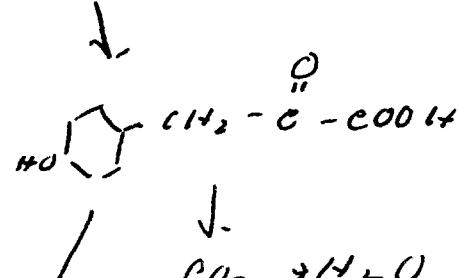
(double recessive genes)

γ -form. succose

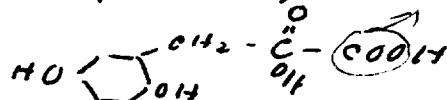


(- -) double recessive
genes in some people
making this reaction
impossible or blocked.

phenyl-ketonuria



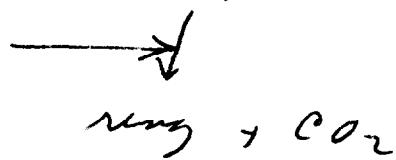
\downarrow rearranged



\downarrow

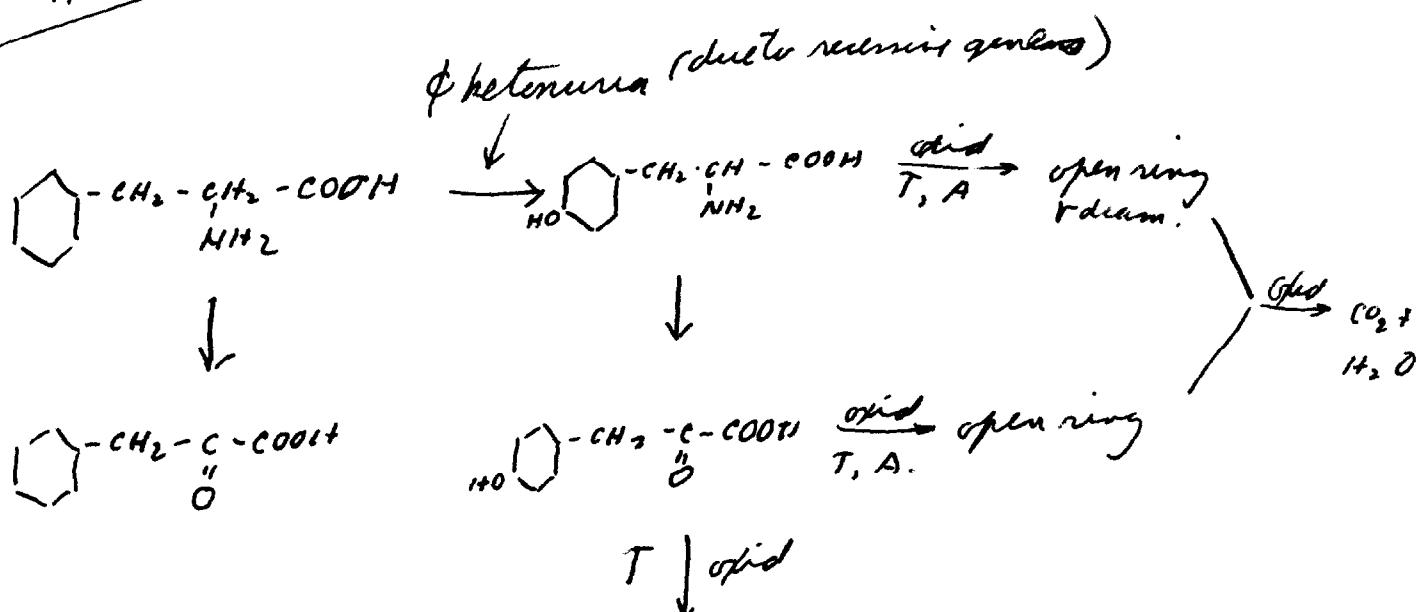
homogenitalic acid

Tyrosinuria
due to double
recessive genes.

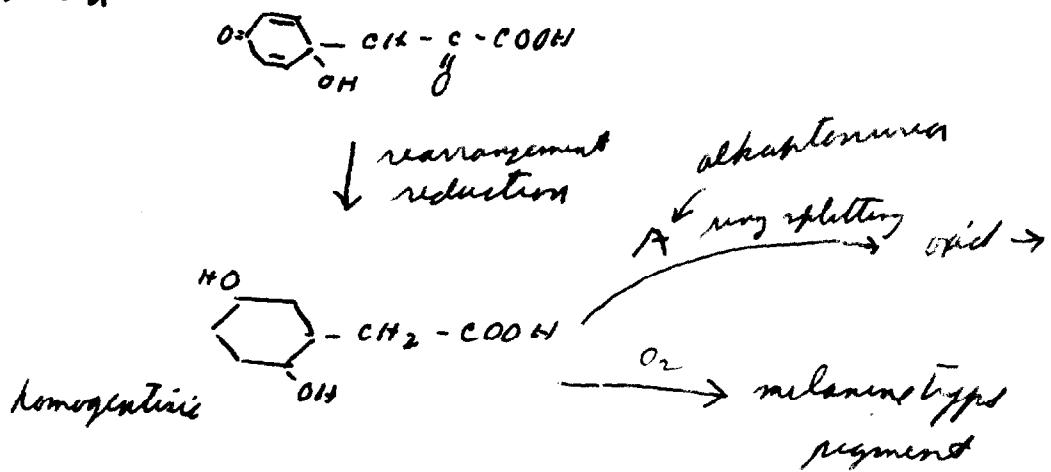


2/27/41

(42.)

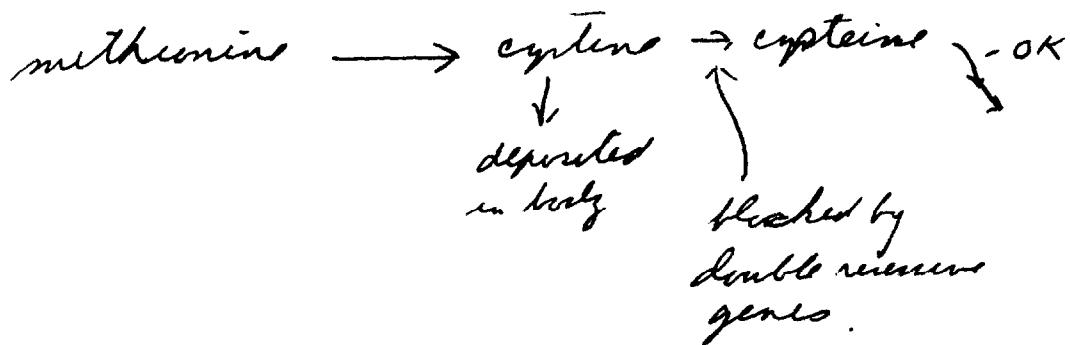


T = tyrosinuria



These reactions may be blocked with incomplete metabolism due to presence of recessive genes.

Cystinuria : - involves metabolism of methionine



Porphyria :-

Uric acid is excreted by man, apes & Palmatress
deg.

- other mammals :-



a = allantoinase

~~++~~

—o—

Hemophilia \rightarrow lessability of blood to clot.

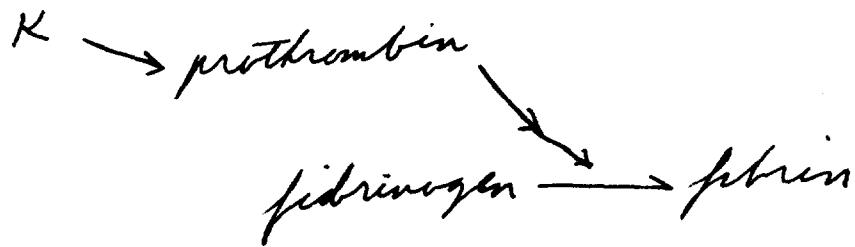
+ = normal
a = recessive

(+) \rightarrow normal clot

(aa) \rightarrow double recessive
homozygous - no blood clot.

(continued next page)

Clothing mech:-



euglobulin fraction (++) \rightarrow normal clot

- apparently euglobulin fraction synthesis is tied up with above normal clotting mechanism

— o —

There are 4 blood groups :-

agglutinogens

A A

A B \rightarrow I

O O \rightarrow neither

B B = ~~(A)~~

A O : (A)

— o —

Chlorophyll synthesis :-

(a) double recessive genes - block chlorophyll synth.

- there are any one to number of genes which may be (aa) a block chlorophyll synthesis.

Storage of Xanthophylls in rabbit fat cells

- destruction of xanthophylls in rabbit fat cells is dominant. Non destruction is recessive

Genetic characters of a certain corn, "nana"

nana - dwarf corn

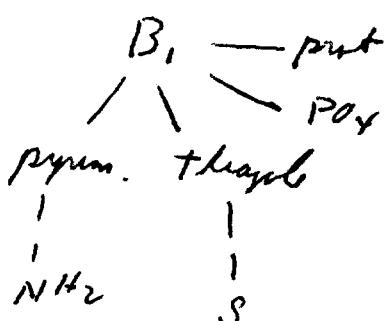
- morphological condition due to auxin (rec. necessary for elongation of cells)
- auxin presence or absence depends upon genes

How genes effect or are involved in chem reactions

- (a) - multiple genes affecting same reactions

such as in synthesis

of B_1



a chlorophyll synth

chlorophyl

genes -	↑

(b) - many genes having an accumulative effect
(each gene responsible for prod. of small
amt of subst.)

example :-

caroten synthesis

↑ ↑ ↑ ↑ ↑
gen gen gen

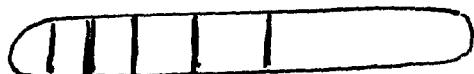
(c) - One gene responsible for complete series /
reactions to specific product.

What do genes do ?

- How do genes bring about certain types
of reactions ?

- Starting with gene itself:-

- can be seen microscopically
- chromosome



→ genes

- much material of chromosome is
nucleoprotein
basic a. a.
nucleic a.

- 4. violet absorption is conc. in above
bands (genes) of chromosome. Here is
where nucleoproteins are concentrated

- Viruses, phage + genes are very similar in chemical composition :-
- all high in basic a.a. content
- max. inactivation of phage 2600 Å
 - same as max abs. of nucleoprotein + genes.
- absorption of diff. viruses is about 2600 Å
- similarity of size of virus : - 250 mpm
 phage : - "
 genes : - "
- all can reproduce - exertion depends upon living forms or organisms

3/4/41

Invertebrate pigments - Leclercq

Biol. Rev. 15, 273 '40

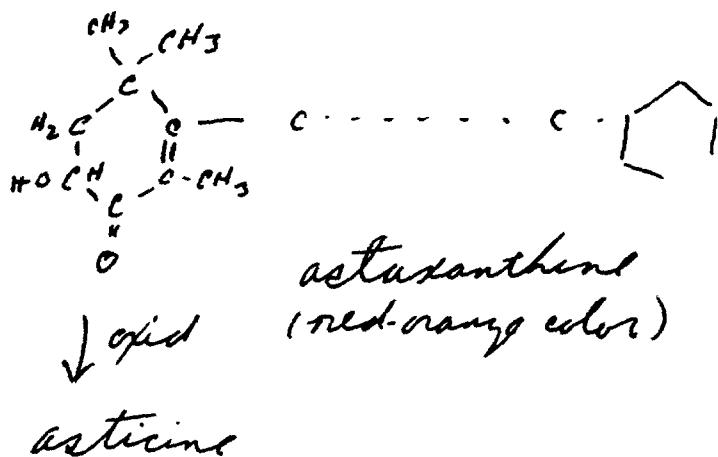
- have unknown attractor + repellent powers - formation of aggregates (virus)
 - attractors + repellent forces of genes + chromosomes
- all can mutate (change species structure)
 - mutation due to ionization effects
 - mutation due to ionization \times radiation - one mutation / quantum

- (45)
- changes or mutations in genes
 - gene molecule altered (polymerization, isomerization etc.)
-

Starting with End Products (as means of characterizing viruses, phages & genes).

Pigments found:-

- carotenoids (eggs & sex glands of invertebrates)



astaxanthin
↓ oxid (red-orange color)

asticic

prolent asticic (greenish)

$\int \text{R}^{\text{700}} \approx$
red.

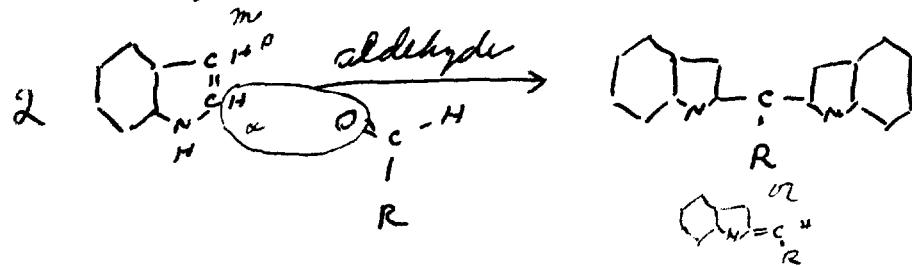
- pyrrole pigments (chlorophyll etc.)
- pterines - 3-pyrimidine rings
- variety of miscellaneous pigments indigo etc.
- melanins (most important pigment)

from a general pd. of view).

- are soluble in alkalies.

- More about melanins

(i) Chem. prep: -



if aromatic aldehydes used:-

prod. is stable + crystallizable
(such as p -diMe NH_2 ϕCHO)
(pH indicators)

if aliphatic aldehydes used:-

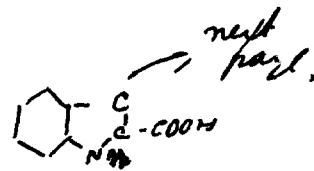
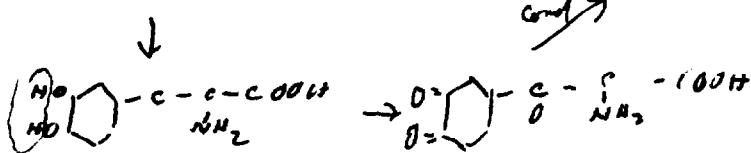
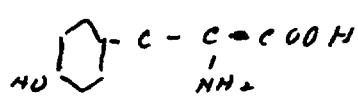
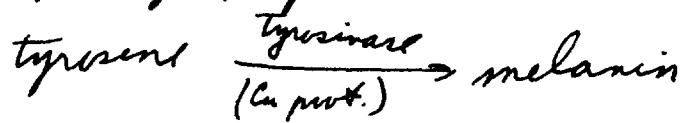
prod. tends to polymerize

(ii) - Photosynthetic melanins

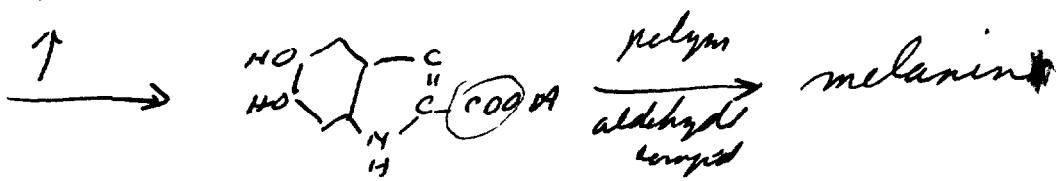
u.v on Palan - Tyrosine - Trypt.
neutral

alkaline soln.

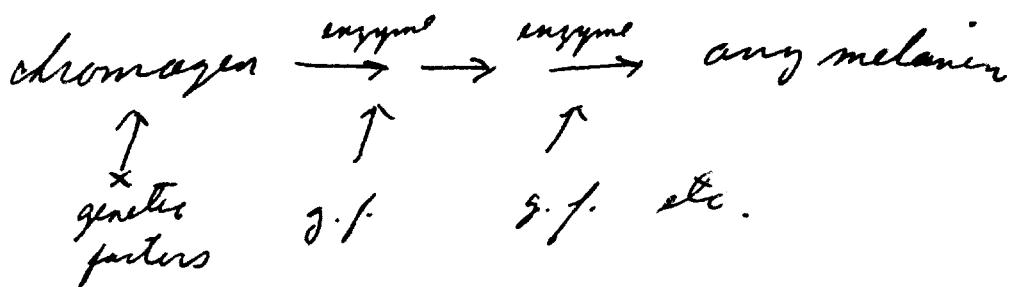
(iii) Biologically significant production :-



heterochromes



Genetic control of other types of reactions forming melanins:-



X - dominant form - produce enzymes

0 - recessive - not " enzymes

X₀ - heterozygous - produces enzymes

Example of genetical analysis involving chemical reactions (melanin prod.)

Himalayan Rabbit :-

AA concerned with oxidizing enzymes production
aa no or very little " "

Extraction of animal

extract $\xrightarrow{\text{iodo-dopa}}$ AA > aa

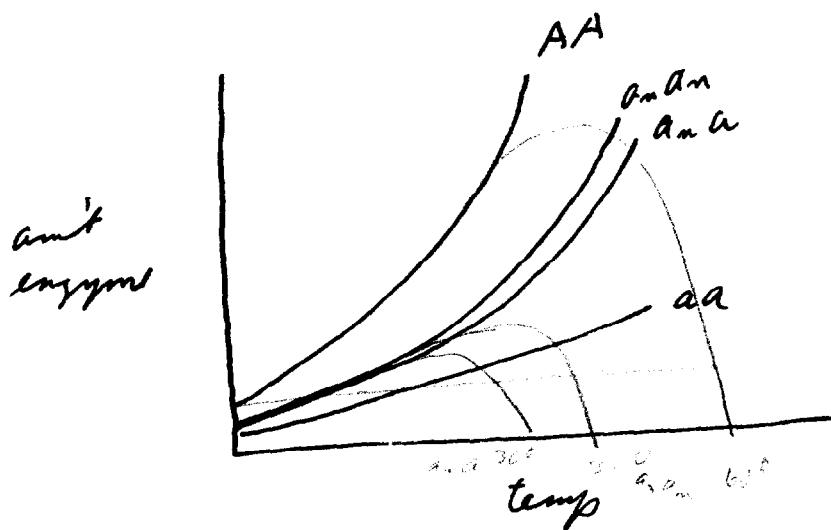
case of:-

peptides - only in tips of extremes (causes
subject animal to temp $> 35^{\circ}$ no pigment
 $< 33^{\circ}$ - pigment prod.
used)

Duck animals have

aa AA genes - intermediates don't
oxidizing enzymes prod.

aa aa genes also



Increase temp & get increase rate
of maturation

3/6/41)

A = enzyme

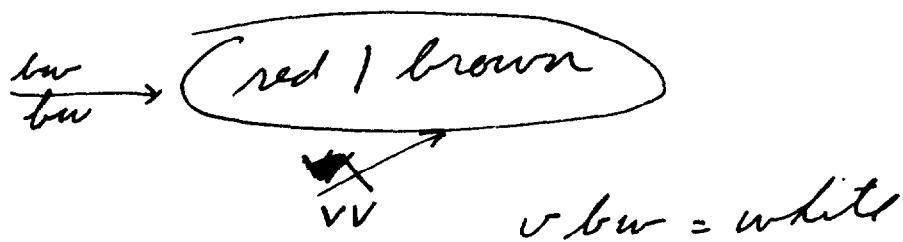
a_n = less enzyme

a = no enzyme

AA > Aa > a_na_n > a_na > aa

Insect pigments

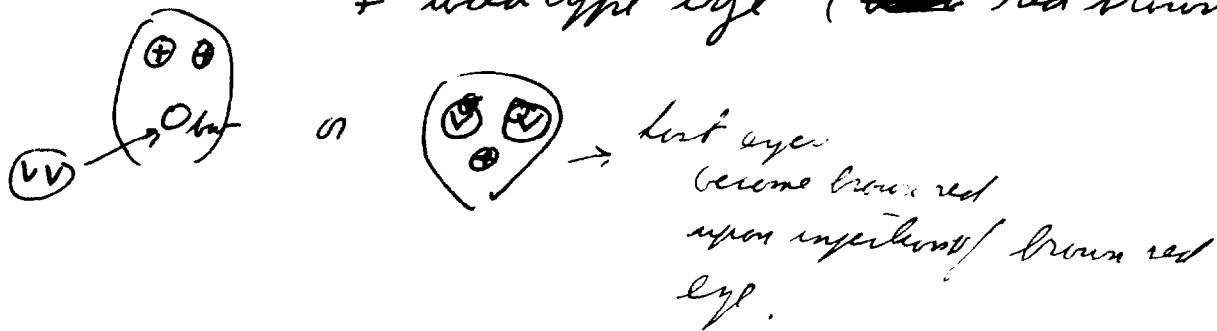
+ wild insect :- normal pigment is red + brown



vv = vermillion

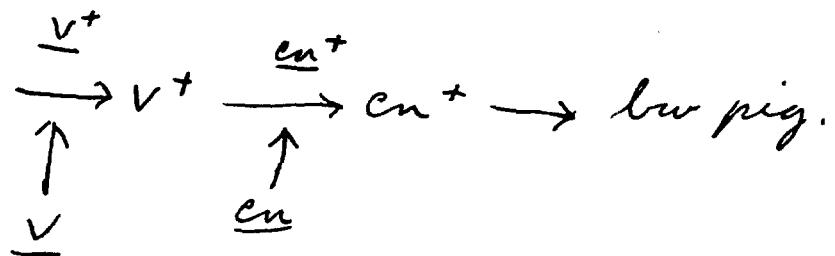
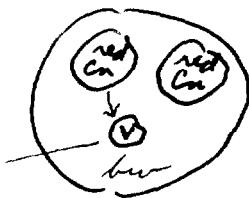
bw = brown

+ wild type eye (~~red brown~~)



non-autonomous

Cn - cannabar
red



$v (-v^+)$

semi starvation \rightarrow bw

\rightarrow results in production
of v^+ hormone

+ tryptophans to $v^- \rightarrow$ bw

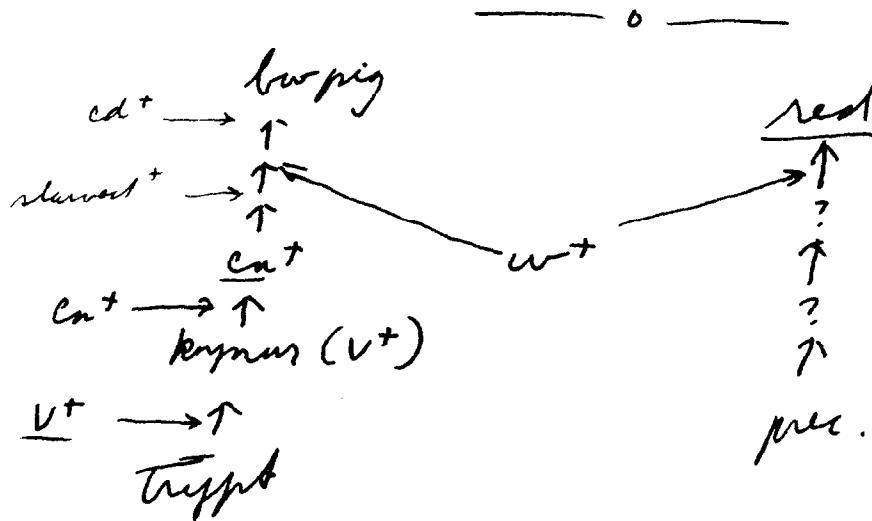
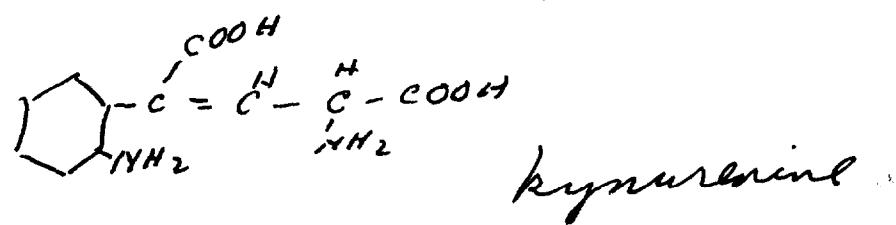
- but under aseptic condition
trypt effect was negative

(trypt + mercury) are necessary, to

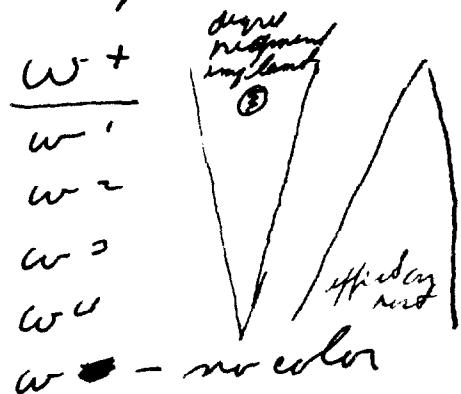
replace v^+ hormone.

(trypt + mercury) \rightarrow bw

V^+ substance is derived from tryptophans: -



w genes



Nature of the pigments :-

Brown (Brown) pig - insoluble (H_2O)
 $\xrightarrow{H^+}$ - oxidized - alk. soln.
 γ -colours
 - soluble acid alcohol.

This pigment may be melanoid
in character

Red pig - completely H_2O soluble
- may be a pterin containing
 3 purines

shades $\xrightarrow{[H^+]}$ red pig $\xrightarrow{[O^-]}$ colored

yellow acid \leftarrow pH \rightarrow red alk

3/11/41

(49)

Scott-Moncrieff - Jour. Genetics, 32, 117 (1936)

Control of Pigments in Insects - review

- controlled by genes
- can be modified by experimental condition
- chem changes as regards insect pigments are brought about genetically
- Reactions rather than precursors of pigments are controlled by genes (actually enzymes which catalyze reactions)
- Dominant gene has positive action (produces enzyme etc.)
- Recessive gene has neg. action (no production of enzyme)

Example :-

V - no V^+ hormone (hypomenes)

\underline{V}^+ converted cn^+ \rightarrow pig

cn - \underline{V}^+ no cn^+

w - $\underline{V}^+ \underline{cn}^+$ no pig

lw - no red has hormones

(OVIDE)

V bw = white

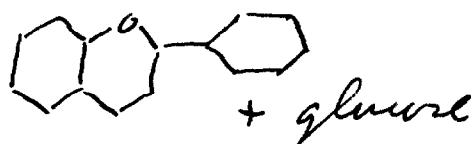
CN bw = white V^+

VW — V^+ $\rightarrow CN^-$

—

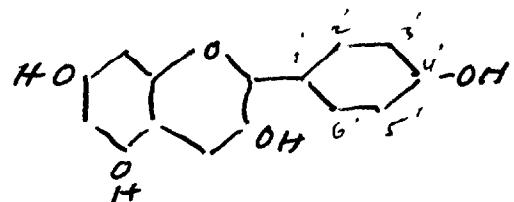
General nature of plant pigments, the way they are controlled genetically.

Main type of pigment: - anthocyanins



~~- H_2O~~

- pelargonidin: -



anthocyanins usually occur in plants as glucosides

- colors of anthocyanins cover blue to red.

- anthocyanins $\xrightarrow{H_2O}$ anthocyanidin + glucose or some other sugar.

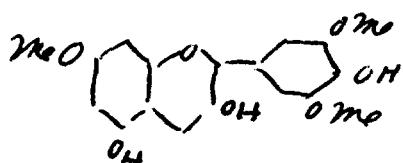
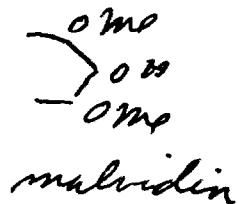
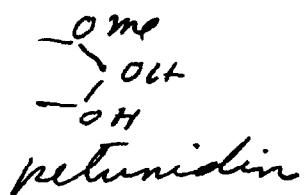
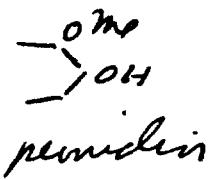
(anthocyanins)

Classification of plant pigments, according to degree of blueness

3', 4' di OH = cyanidin

3', 4', 5' tri OH = delphinidin

ox more
 → blues



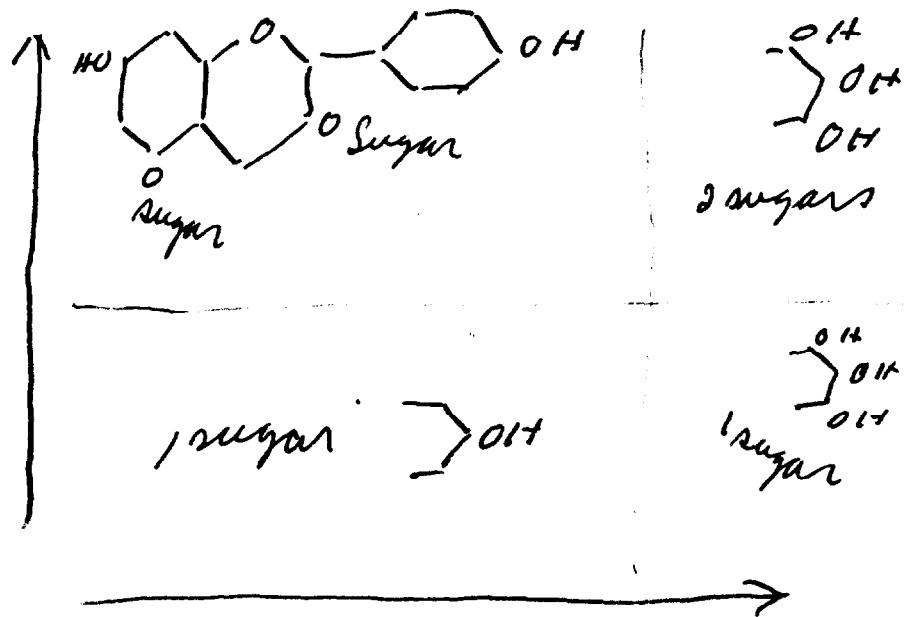
hirsutidin

more methylations → less blue

Factors controlling pigment

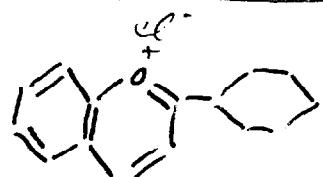
- (1) - increased blueness by oxidation
- (2) - decreased blueness with methylators
- (3) - sugar residues increase blueness
- (4) - pH affects color & intensity of color.
- (5) - Co-pigmentation intensifies blue (anti-quenching)
- (6) - Colloidal state

- verbena



- blueness increases in direction of arrows.

Effect of pH on color :-



acid -

oxonium salt

red

neutral

inter-
mediates

No OH

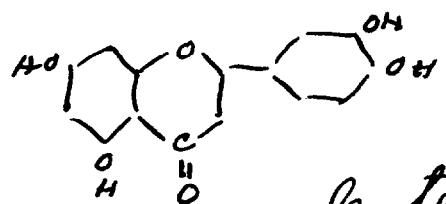
blue

Other types of pigments in plants

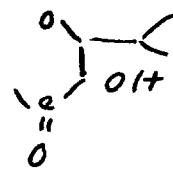
carotenoids

xanthophylls

anthoxanthins : -



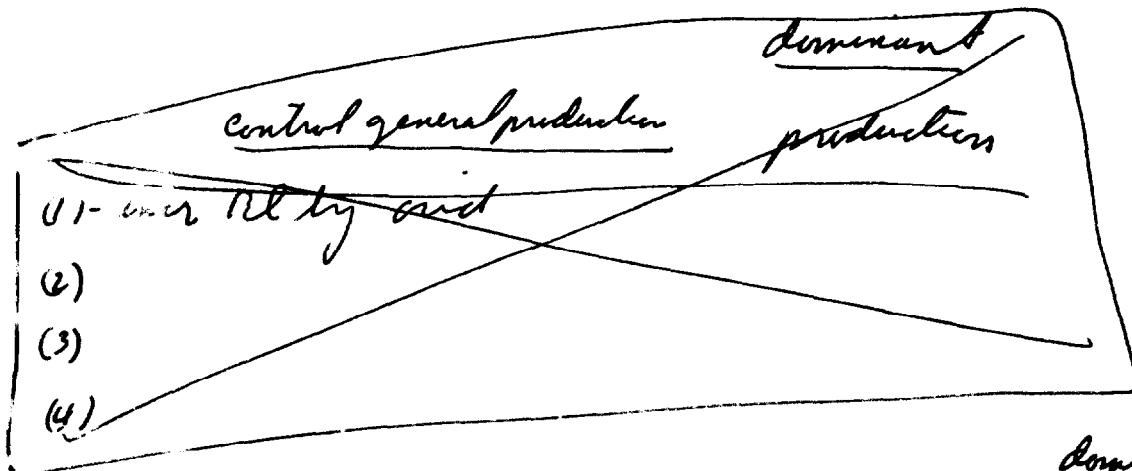
Lentolin



Quercitin

- very much less intense in color
- owing to yellow
- the many varieties have marked effect on anthocyanins. This is called co-pigmentation (intensifies blueness of an anthocyanin).

Correlation of pigment controlling factors & genetic control :-



- control general production - dominant production
- specific prod. - production
- (1) max Bl. by grid -- grid
- (2) deer Bl. with me -- methylators
- (3) sugar res. - intens - complexity of sugar residues
- (4) pH change - lower pH production (i.e., organic acids)
- (5) Co-pigmentation - prod anthocyanins

There is a competition effect between anthocyanins & anthoranthens which is controlled genetically

3/13/41

General Review

- Methods of obtaining energy :-
 - evolutionary development
 - mechanisms & reactions involved
 - respiratory mediators
 - similarity of mechanisms in various scales of life.
 - nucleotides, coenzymes, enzymes, C₄ dicarboxylic acids etc.
 - analogues of amine acid + carbohydrate catabolism
 - energy obtained + its utilization for life
 - growth
 - restoration of cell material, hence synthesis
 - Syntheses by cell
 - carbohydrates, a.a., proteins etc
 - however, some things can't be synthesized by organisms (vitamins etc.). This represents a progressive loss of power to synthesize by the organism

- Vitamins probably function as catalysts
- ability to synthesize a.a.
 - nature of essential a.a.
 - " " " none " a.a.

Validity of assumption that all ^{metabolic} processes are essentially the same or related

Structural characteristics of organisms

Reactions

" " "

- Both are controlled by specific enzymes

Enzymes:- adapters
 specific

- controlled genetically

Some aspects of genetics play

- similarity to virus & ~~bacteria~~
- size, composition of proteins and of viruses, plasmids & genes.

- cause of mutations

Types of reactions which can be modified or controlled genetically.

- vital modifications of metabolism
- non-vital " γ , rays, pigment

Genes have a positive effect

- dominant gene
- prod. of enzymes etc.

- mutation of genes involves loss of a function - recessive genes

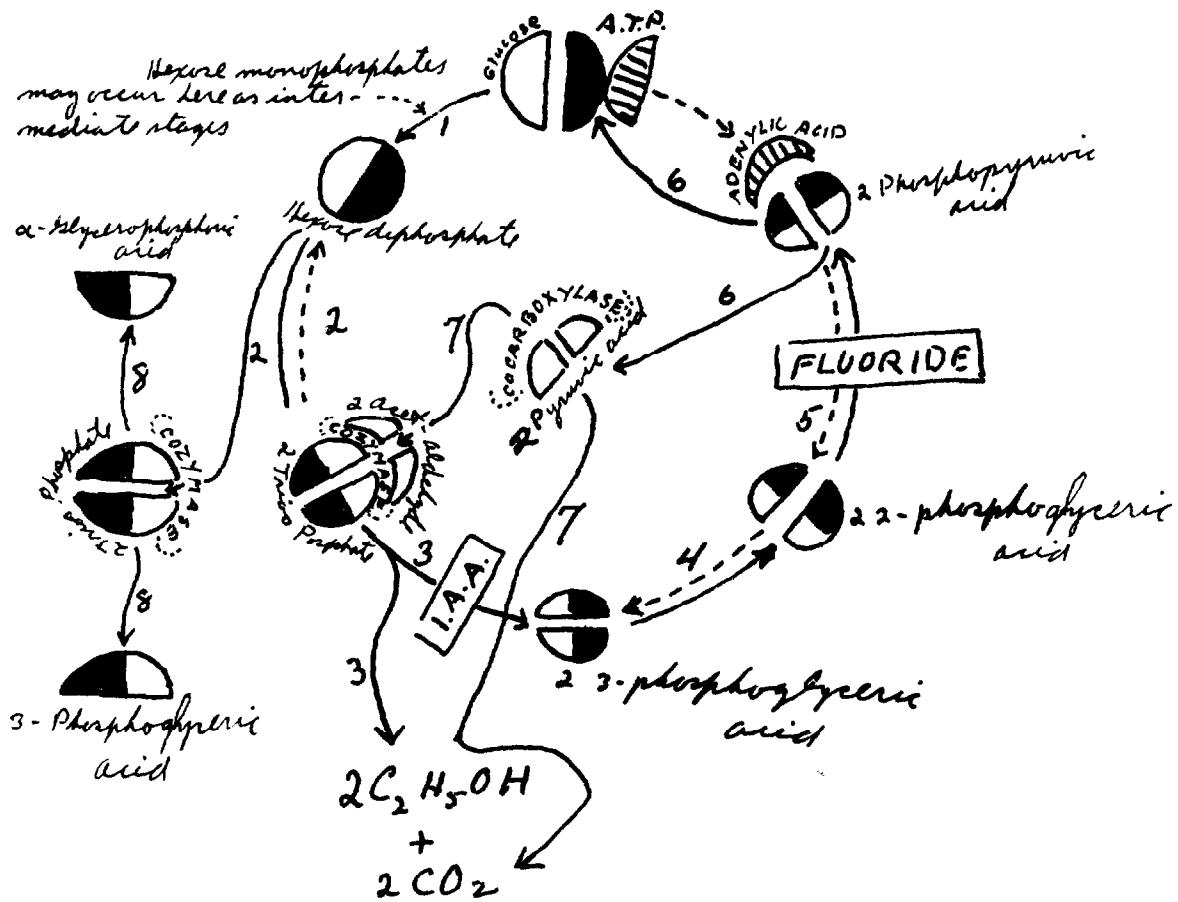
general nature of actions of genes.

- blocking of reactions
- a way of arriving at actual no. of chemical steps in a synthetic process.

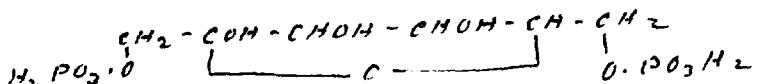
Assume that all processes in cells are genetically controlled.

Current Theory of Fermentation of Hexoses

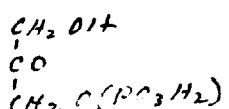
Glucose



Glucurone
Fructose-furanose 1:6-diphosphate :-



Dihydroxy acetone phosphate: -



3-Phosphoglyceric acid: - $\text{CH}_2\text{O}(\text{PO}_3^{\text{H}_2})\text{CHOH}\cdot\text{COOH}$

$$2 - \text{NH}_2\text{OH} \cdot \text{C}_1\text{H}_4\text{O}(\text{PO}_3\text{H}_2) \cdot \text{COOH}$$

Phosphopyruvic acid :- $\text{CH}_2 = \text{CO}(\text{PO}_3\text{H}_2) - \text{COOH}$

Pyrone area :- $\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_2=\text{C}(=\text{O})\text{COOH}$

acet aldehydes :- CH_3CHO

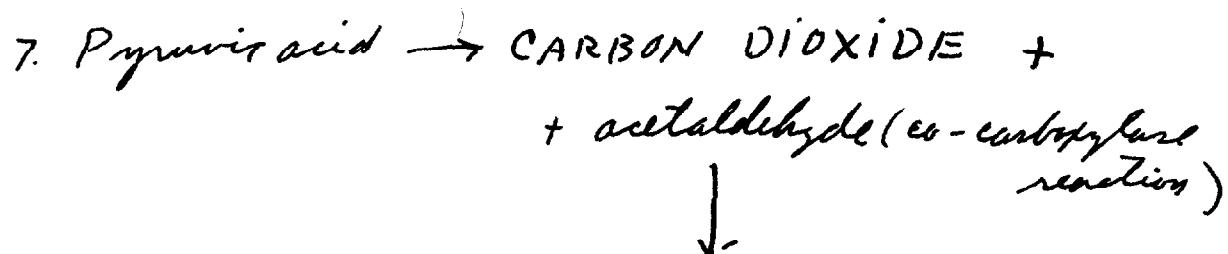
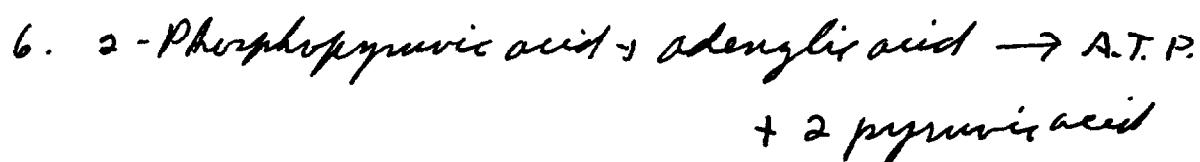
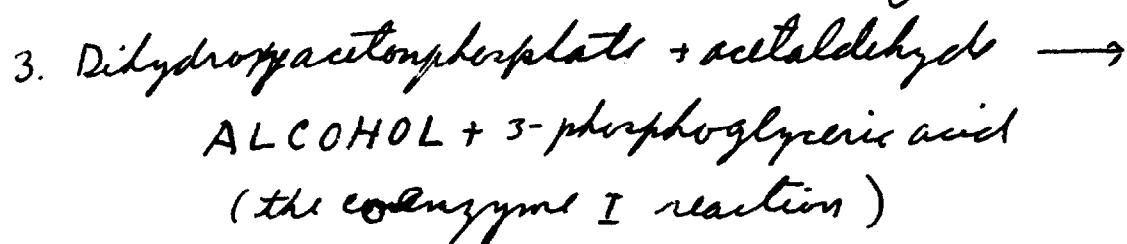
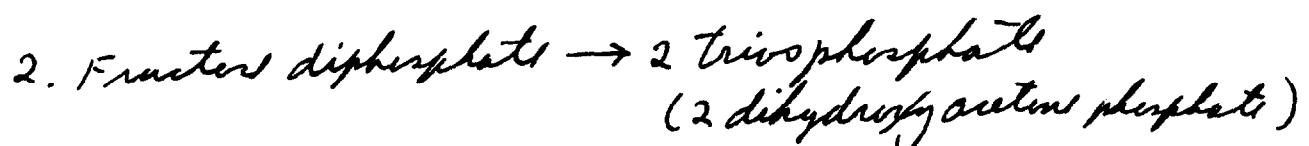
Alcohol : C_2H_5OH

Carbon Dioxide :- CO_2

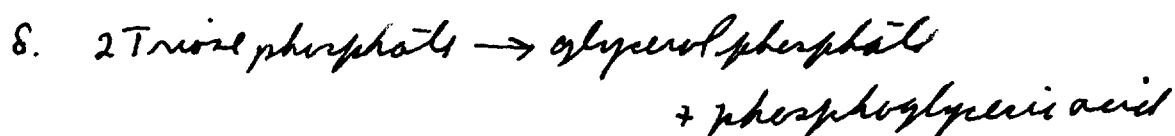
Starting at the point where glucose enters the machine
the first action is that of phosphorylation : -



The hexose molecule now remains phosphorylated till the final stage of degradation is reached and the intramolecular changes and oido-reductions all occur in phosphorylated molecules.

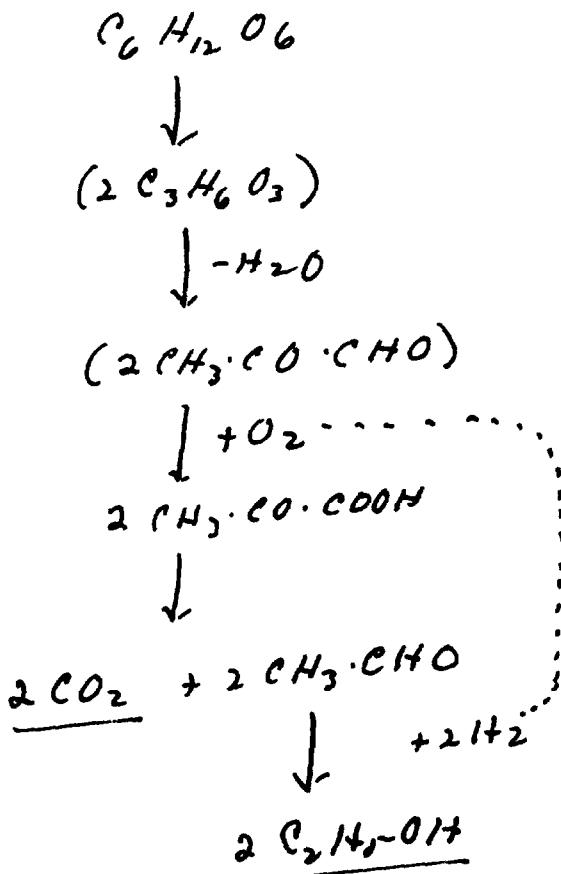


To equation (3)

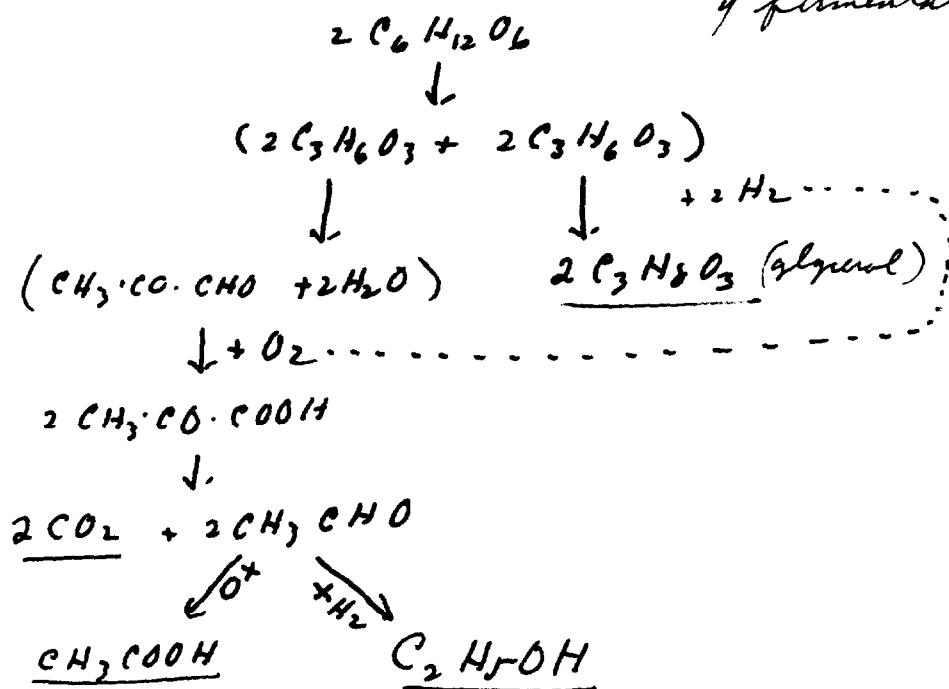


Earlier work by Newberg :-

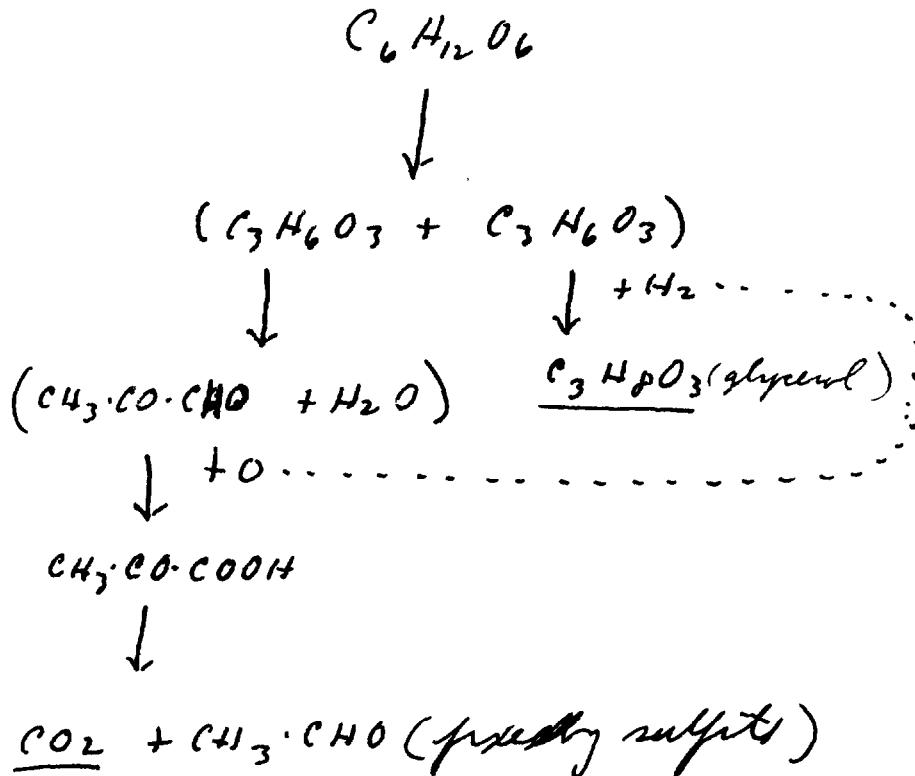
Scheme I (Newberg's "first form" of fermentation)



Scheme II - If reaction of medium is alkaline
 (Newberg's "third form" of fermentation)

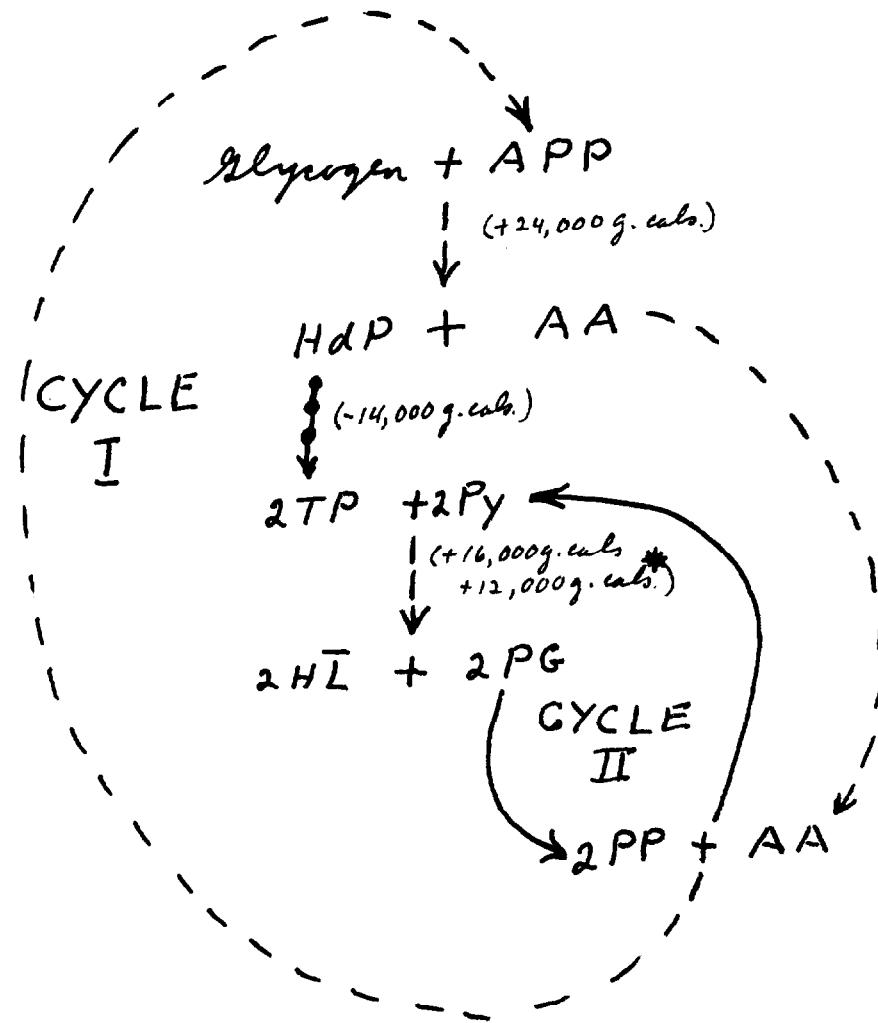


Scheme II (Newberg's "second or fixation form" of fermentation)



Chemical Cycles in Muscle Contraction

Scheme I



APP = adenylyl pyrophosphate

Py = pyruvic acid

HDP = hexosediphosphate

HL = lactic acid

AA = adenylic acid

PG = phosphoglyceric acid

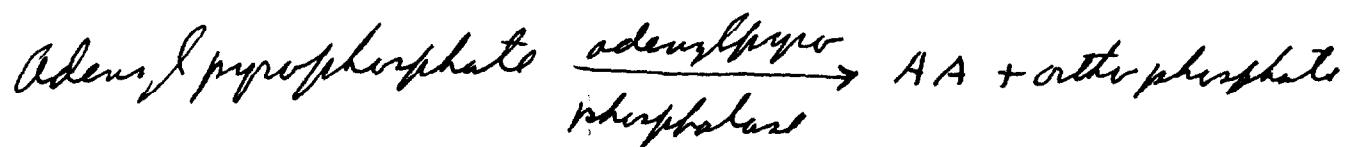
TP = triosephosphate

PP = phosphopyruvic acid

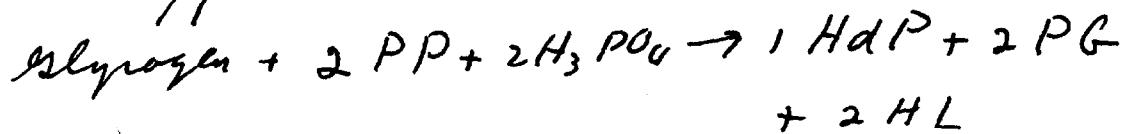
* This 12,000 g. cal. is due to neutralization by protein
of the acid formed.



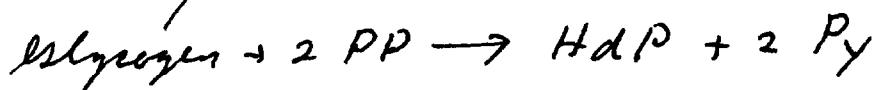
Here the heat provided by hydrolysis of one molecule of adenylpyrophosphate is just about equivalent to that needed for synthesis of two molecules of creatine phosphate - the reaction is thermally neutral.



In presence of fluorid:



In presence of iodacetate:



Scheme II - (for happening during anaerobic recovery).

- I. Glycogen + 2 H₃PO₄ → 2 hexosemonophosphate
- II 2 hexosemonophosphate + 2 adenylylpyrophosphate → 2 hexosediphosphate + adenylic acid (+ 24,000 g. cal.)
- III 2 hexosediphosphate ⇌ 4 triosephosphate (- 28,000 g. cal.)
- IV 4 triosephosphate, 4 pyruvate → 4 phosphoglycerate + 4 lactate (+ 32,000 g. cal + c. 24,000 g. cal.)
- V 4 phosphoglycerate → 4 phosphopyruvate (\pm 0 g. cal.)
- VI 2 phosphopyruvate + adenylic acid → 2 pyruvate + adenylylpyrophosphate (- 7400 g. cal.)
- VII Adenylylpyrophosphate + 2 creatine → 2 creatinephosphate + adenylic acid (+ 100 gm. cal.)
- VIII 2 phosphopyruvate + adenylic acid → 2 pyruvate + adenylylpyrophosphate (- 7400 g. cal.)